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الجامعة الأردنيـــــة
كلية الدراسات العليا

التاريـــخ: ١٩ / ٥ / ٢٠١١

نموذج رقم (١٨)
اقرار والتزام بالمعايير الأخلاقية والأمانة العلمية
وقوانين الجامعة الأردنية وأنظمتها وتعليماتها
لطلبة الماجستير

أنا الطالب: محمد سعيد عبد الهادي الغانم الرقم الجامعي: (8080398)

تخصص: هندسة مدنية / نقل الكليـــــة: الهندسة

عنوان الرسالة: العلاقة بين مستوى الخدمة ونسبة حوادث الطرق الشريانية في عمان

اعلن بأنني قد التزمت بقوانين الجامعة الأردنية وأنظمتها وتعليماتها وقراراتها السارية المفعول المتعلقة باعداد رسائل الماجستير عندما قمت شخصيا" باعداد رسالتي وذلك بما ينسجم مع الأمانة العلمية وكافة المعايير الأخلاقية المتعارف عليها في كتابة الرسائل العلمية. كما أنني أعلن بأن رسالتي هذه غير منقولة أو مستلة من رسائل أو كتب أو أبحاث أو أي منشورات علمية تم نشرها أو تخزينها في أي وسيلة اعلامية، وتأسيسا" على ما تقدم فانني أتحمل المسؤولية بأنواعها كافة فيما لو تبين غير ذلك بما فيه حق مجلس العمداء في الجامعة الأردنية بالغاء قرار منحي الدرجة العلمية التي حصلت عليها وسحب شهادة التخرج مني بعد صدورها دون أن يكون لي أي حق في التظلم أو الاعتراض أو الطعن بأي صورة كانت في القرار الصادر عن مجلس العمداء بهذا الصدد.

توقيع الطالب:............................ التاريخ: ١٩ / ٥ / ٢٠١١

RELATIONSHIP BETWEEN LEVEL OF SERVICE AND TRAFFIC ACCIDENT RATES IN AMMAN ARTERIALS

By

AL-Ghananem, Mohamad Saeed

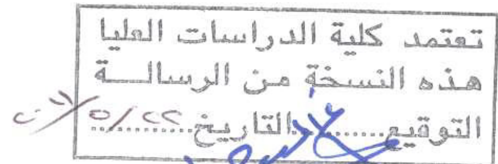
Supervisor

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This Thesis was Submitted in Partial Fulfillment of the Requirements for the Master's Degree of Science in Civil Engineering

Faculty of Graduate Studies

The University of Jordan

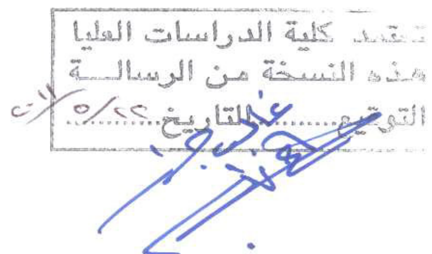


May, 2011

COMMITTEE DECISION

This thesis / Dissertation (Relationship between level of service and traffic accident rates in Amman arterials) was successfully defended and Approved on 10 /05 /2011

Examination committee	Signature
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TABLE OF CONTENTS

List of Tables

List of Figures

ABBREVIATIONS

AADT	Annual average daily traffic, veh/day
ADT	Average Daily Traffic
AR	Accident Rate per 1 million v-km
BFFS	Base Free-Flow Speed, km/h
D	Density, veh/km, pc/km/h, or veh/km/ln
DDHV	Directional Design-Hour Volume, veh/h
FFS	Free-Flow Speed, km/h
GAM	Greater Amman Municipality
GDP	Gross Domestic Product
GIS	Geographic Information System
GNP	Gross National Product
HCM2000	Highway Capacity Manual 2000
LOS	Level Of Service
NJ	New Jersey
NJDOT	New Jersey Department of Transportation
PDO	Property Damage Only Accidents
TPD	Traffic Police Department
TRS	Traffic Recording System
TWLTLs	Two-way left-turn lanes
V/C	Volume / Capacity
WHO	World Health Organization

RELATIONSHIP BETWEEN LEVEL OF SERVICE AND TRAFFIC ACCIDENT RATES IN AMMAN ARTERIALS

By

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Supervisor

Dr. Adli Al-Balbisi, Prof

ABSTRACT

The relationship between the level of service and road traffic accident rates is derived in this study for Multilane divided arterials in Amman City. Specific measures and recommendations were proposed to ensure traffic safety under different levels of service. Correlations between accident rates and traffic flow conditions; level of service (LOS), are investigated.

The traffic density and the LOS were determined for different arterials in Amman city on an hourly basis for the period of six months from July to December, 2010. It is noted that 20% of daytime traffic density declines below 7 pc/km/lane, resulting in a level of service “A” which generally extends for six hours from 1:00am to 7:00am, while the LOS ”F’’ prevails for more than 50% of the remaining time.

Traffic accidents were classified into injuries and Property Damage Only (PDO). The findings of the study show that while 17% of traffic accidents involved injuries, 50% of injury accidents occurred under LOS “F” operating conditions. The percent of injury involvement in traffic accidents increased linearly from level of service “C” to “F”.

The finding of this study, show that most of Amman arterials in this study have a prevailing LOS “F” for about 30% of the time, 55% of the accidents occur during LOS “F”. In other words, enhancing LOS from “F” to “E” only shall reduce the total number of accidents by 27%.

The developed polynomial model that relates the rate of accidents to traffic density was of the following form:

$$\mathrm{A} = 0.0023\ (\mathrm{D})^2 - 0.06496\ (\mathrm{D}) + 1.9624$$

where; *A*: rate of Accidents expressed in accidents per million vehicle

D: traffic density expressed in pc/km/lane

This model is used to predict the number of traffic accidents along different arterials under various prevailing road and traffic conditions in Amman.

1. INTRODUCTION

1.1 Background

The problem of road traffic accidents is not a local problem experienced by any single country, it is considered as a global concern cause problems to all the nations around the world, and implies negative repercussions on societies. Road accidents appeared since the invention of vehicles, but the treatment and mitigations were not taken into consideration till the sixties, where same advanced countries took advanced scientific approach to reduce the overhang problem and to reduce the accident rate in those countries. In many developing countries, the situation has deteriorated, increasing road accidents, and consequently increased the losses of human, social and economic resources.

Traffic accidents are the leading cause of death among young people aged between 10 and 24 years. The report, which was issued under the title, "Youth and Road Safety" [13], mentions that traffic crashes annually cause a worldwide loss of nearly 400,000 young people under the age of 25 and injured millions of young people or disabled them. The costs of traffic accidents in many low-income and middle-income countries go, between 1% and 1.5% of Gross National Product (GNP). In some cases this overcomes the amount of international development aid received.

The fatalities and serious injuries resulting from traffic accidents became a major problem that threatens the lives of people in Jordan during the past years. The percentage of traffic accidents has increased to the global level significantly, resulting in a significant increment in the number of serious injuries and fatalities.

The annual cost of traffic accidents increased in Jordan from JD 170 million in 2002 to JD 258 million on 2009 where the number of fatalities decreased from

758 in 2002 to 676 in 2009. Every 5 minutes an accident takes place in Jordan, every 29 minutes crash involved injuries, and every 9 hours a fatality observed due to traffic accident.

1.2 Objectives of the study

The rate of accidents on the roads depends on several factors; speed, traffic volume, and both longitudinal and transverse distribution of vehicles, in addition to the types of vehicles, number of lanes, dimensions and density of access roads and intersections.

The main objective of the study is to develop relationship between the rate of road accidents and the road's Level of service. The LOS is described by the numerical value of traffic density. The following factors will be considered indirect as per highway capacity manual procedure (HCM):

- Free flow running speed (km/hr),
- Traffic flow rate (pc/h/ln)
- Traffic volumes,
- Longitudinal and transverse distribution of vehicles,
- Traffic composition,
- Geometric design of the road, and
- Number of access points to the highway.

1.3 Organization of Thesis

The main body of the thesis consists of the following chapters**:**

Chapter-1 Introduction: introduces the needs for a further studies and mitigations to reduce the traffic accidents, and discusses the importance of studying the highway level of service in expecting the rate of accident for a multilane highway portion.

Chapter-2 Literature Review: summarizes the related literature, which focused on the relation between road section, traffic volumes and the rate of accident. This was done to avoid unnecessary duplication of research and to concentrate on non covered areas as the introduction of statistical model to predict number of accidents knowing the highway level of service for local arterial in Amman city.

Chapter-3 Data Collection and calculations: identifies the data source. Also provide the calculation of the multilane highway level of service based on Highway Capacity Manual 2000 (HCM2000).

Chapter-4 Data Presentation: summarizes the results of the study for Amman arterial in both tabular and graphical forms and correlates the number of accidents with traffic density.

Chapter-5 Data modeling: addresses the correlation charts and the related model to predict the number of accidents in terms of highway density for each arterial. Thereafter, a model will be presented and validated along with the individual arterials' results.

Chapter-6 Conclusions & Recommendations: summarize the list of findings and discuss the practicable applications of the resulting model.

2. Literature review

Many studies have been conducted in order to examine the impact of road section, traffic volumes, density and level of service on rate of accidents some of these are:

- "Levels of service and road traffic accident rate" [3],
- "Accidents on suburban highways-Tennessee's experience" [10],
- "Relationship between child pedestrian accidents and city planning in Zarqa, Jordan" [1]
- "Role of road user and roadway geometric in road accident in Jordan" [2]
- "Level of service (LOS) for multilane highway and road accident information system development of Pa`hat area" [9]
- "Impact of access driveways on accident rates at multilane highways" [8]

Other related literatures were referenced for other roads classification as:

- "Effects of Traffic Condition (v/c) on Safety at Freeway Facility Sections" [7]
- " Modeling signalized intersection traffic accidents" [11]

This study concentrates on the development of mathematical model to predict rate of accidents knowing the highway density for local arterials in Amman city.

The following paragraphs summaries of the previous studies outlined above issue:

Chvanov ,V et. al [3] The relation between highway level of service and accident rate was discussed by the author. Special measures were recommended for ensuring traffic safety under different levels of service on different types of highways. The author investigated the impact of traffic load level upon the accident density for various types of roads running through developed and through out-of-town areas. The investigation, which was based on extensive information concerning the condition of the Federal Road Network, confirmed in general that traffic load level played a considerable role in building up accident rate. This relationship will be further investigated in this study for Amman arterials.

Richard et. al. [10] As part of a larger effort to develop guidelines for the design of arterial roads in areas undergoing suburbanization, a safety analysis of median design was undertaken using Tennessee data. The two median designs investigated were continuous two-way left-turn lanes (TWLTLs) and raised medians. Author study sections had four basic through-lanes and were located in areas with various degrees of typical suburban commercial development (i.e., strip development). Several statistical techniques (analysis of covariance and multiple regression analysis) were used to determine the relative safety of the two designs. The author study was limited to highways where average daily traffic volumes were less than or equal to 32,500 vehicles per day. For this volume range, the author concluded that medians are generally safer than TWLTLs, but certain conditions exist where TWLTLs would have more favorable safety experience (high driveway densities and low to medium traffic volumes). Regression analysis revealed that driveway density is an important contributor to accidents for medians but not for TWLTLs. All cases considered in this

study for Amman arterials were selected with raised median to study the relationship between accident rates and traffic density.

Al-Balbissi et. al. [1] The relationship between child pedestrian accidents and city planning was studied in Zarqa, Jordan. Variables considered included road pattern, road density, population density, size of green areas, and number of schools in the area. Data were collected for child pedestrian accidents from police records. Analysis of these data revealed several conclusions among which is that children 5 to 9 years of age accounted of 33% of the total number of pedestrian casualties and 49% of child pedestrian casualties. This group constituted about 17% of the total population of Jordan. The city was divided into 16 study zones and statistical analysis was performed using multiple regression techniques. Significant relationships were obtained by the author between child pedestrian accidents and several land use variables. Developed models proposed to be used to give an estimate of the reduction in child accidents because of changes in road pattern and other variables as road density. According to author, a 25% reduction in the number of four-leg (cross) intersections could reduce accidents by approximately 24%. A focus on the road density role in reduction of the number of accidents is introduced in this study for Amman arterials.

Al-Balbissi et al. [2] Jordan's road network has been one of the fastest growing systems in the area and promises to continue developing in the coming years. In order to continue this development, the Jordan authorities are searching for means to improve road safety and management practices. The authors undertake research in Jordan with a view to establish the nature and extent of its traffic accident problems, and in the longer term to assess the effectiveness of remedial measures. Special emphasis was given to the effect of road users and geometrics on road accidents.

Road users were found to be responsible for about 95% of all accidents. In this study, the role of road geometry in traffic accident rate for Amman arterials is highlighted.

Bin Abdullah Moh'd [9] The Level of Service (LOS) for Multilane Highway and Road Accident Information System (LORIS) was developed in Malaysia. The main function of LORIS is to analyze LOS which is very important issue for traffic engineer because it describes the traffic operational conditions within a traffic stream. Besides that, road accident data and basic highway information was also included in this system. In this study, the potential of using this system in traffic and accident analysis were conducted only at Batu Pahat area, which is among the highest road accident rate in Malaysia. The objectives were to develop a database and information system to determine the LOS, road accident information and basic highway information. To achieve this, Microsoft Access 2003 was utilized incorporating with Microsoft Visual Basic 6.0. As the results, an effective computerized LOS calculation system had been developed together with road accident and highway information system. The system has been calibrated and validated to obtain reliable results. In this study for Amman arterials, the use of Microsoft excel 2007 combined with the Traffic Record System (TRS) output files were utilized using VBA macros to calculate the hourly LOS and correlate the results with rate of accidents.

Kyriacos C. Mouskos, et al. [8] The New Jersey Department of Transportation (NJDOT) is enforcing its access management standards within the limits of most of its highway improvement projects. In order to identify the impact of access points on accident rates, a study was conducted that concentrated on NJ State highways Rt. 27, 28, 33, and 35. The study concentrated primarily on the impact of major geometric and traffic flow characteristics on accident rates at the macroscopic level. The principal variables that were taken into consideration included the Annual Average

Daily Traffic (AADT), number of lanes, shoulder existence, median existence, speed limit, and access points per mile (access density). The analyst included a comparative analysis between the occurrences of accidents at signalized intersections (intersection-accidents) and between intersections (section-accidents). In addition, a field study was conducted on one NJ state highway section where the main objective was to provide insights into the microscopic traffic flow characteristics such as the speed profile along the roadway, and the impact of turns from/to access points on the speed of the vehicles traveling on the mainline. The principal conclusions of this study are: approximately 30% of the total accidents on the study routes were reported to occur between signalized intersections, approximately 7% of the accidents were attributed to vehicle maneuvers from/to access points, accident rates are better represented by a log-normal distribution, access density is a contributing factor to the occurrence of accidents between signalized intersections although not a necessary one, the highest percentage of accidents occurred during the evening peak from 3:00 to 6:00 PM, driver inattention is the primary factor in accident occurrence for both the section (37%) and signalized intersection accidents (33%), regression models were developed for 4-lane highway with shoulder, 2-lane highway without shoulder, and 4-lane highway with median that included a combination of the AADT and access density and/or the speed limit as independent variables. A more comprehensive statistical analysis of all NJ state highways and the US is recommended that could identify similarities and differences among various types of highways. This analysis should include sub-hourly traffic flow rates, the distribution of the speed and more detailed geometric characteristics. The development of a detailed GIS based database that would include accidents, traffic flow, geometric and weather characteristics would provide a universal basis for conducting similar analyses. A microscopic simulation model is needed, which can capture the traffic flow characteristics of multilane

highways/arterials, especially capturing the impact of access points. In this study for Amman arterials, the macroscopic level of traffic flow characteristics was considered.

3. Data collection and calculations

3. 1 Data Sources

A number of Amman arterials were considered for which both traffic and accidents data were available and satisfy the requirements of multilane highway as outlined in the highway capacity manual 2000. These arterials are distributed on different locations, contribute to the daily trip activities by citizens, and vary from low to high volume roads with different traffic composition. Figure-1 below shows Amman road map highlighting the locations of the selected sites for this study.



Figure-1: Amman roads map [4]

3.1.1 Description of sites

Greater Amman Municipality (GAM) is responsible for the planning and operating of roads and traffic within its area. Therefore, GAM installed a Traffic Recording System (TRS) at 18 stations distributed as listed in Table-1. These roads are considered main arterials in Amman. Which are divided multilane highways.

Table-1: Traffic recording System stations in Amman [4]

Site ID	Road Name	Site Name in Arabic
I01	Al-Aqsa	شارع الاقصى قبل جسر القصور
I02	Al-Urdon	شارع الاردن قبل تقاطعه مع شارع الاردن
I03	Queen Alia	شارع الملكة علياء قبل دوار الداخلية
I05	Queen Noor	شارع عرار قبل جسر الملكة نور
I06	Zahran	شارع زهران قبل الدوار الربع
I07	APDOun	جسر عبدون قبل الدوار الرابع
I09	Al-Quds	شارع القدس قبل شارع الدستور
I10	Prince Hasan	شارع الامير حسن بعد اشارة المهاجرين
I11	Yarmouk	شارع اليرموك بعد اشارة النشا
I12	King Abdullah 1st	شارع الملك عبدالله الاول قبل تقاطع النشا
I13	Al-Jaish	شارع الجيش من مجمع المحطة وقبل جسر المربط
I14	Al-Jaish	شارع الجيش بعد جسر المربط باتجاه مجمع رغدان السياحي
RSI02	Amman-Madaba	شارع عمان – مادبا
RSI11	Al-Shaheed	شارع الشهيد مقابل مخابز جواد
RSI07	As-Salt	شارع السلط بالقرب من جامعة عمان الاهلية
RSI13	Marca	ماركا قبل اشارة الترخيص
RSI08	Al-Baqa'a- Safout	شارع البقعة / سافوط
RSI06	Dead Sea	البحر الميت قبل نقطة التفتيش

Table-2: Multilane Highway Criteria Selection [12]

Street Name	**Segment Length (m)**	**Traffic Signal Spacing, Km**	**Nearest Signalized I/S (m)**	**FFS Km/hr**	**Posted Speed Km/h**	**No. of Lanes**	**Pedestrian activity**
Al-Aqsa	1400	NA	880	76.9	70	4	Minimal
Q. Alia	1500	NA	NA	71.97	70	6	None
Zahran	1200	NA	NA	70.71	60	4	Minimal
Yarmouk	900	NA	NA	70.23	60	5	Minimal
Jaish	900	4.55	1500	80.01	60	6	Minimal
Shaheed	2000	NA	NA	80.6	90	6	Minimal
HCM	**> 760**	**> 3 km**	**> 400**	**70»100**	**60»90**	**4 » 6**	**Minimal**

Table-2 lists the selected sites and shows the criteria used as a basis of their selection which is in accordance with the HCM criteria. The following paragraphs give a brief description of each selected site.

3.1.1.1. Al-Aqsa Street (I01)

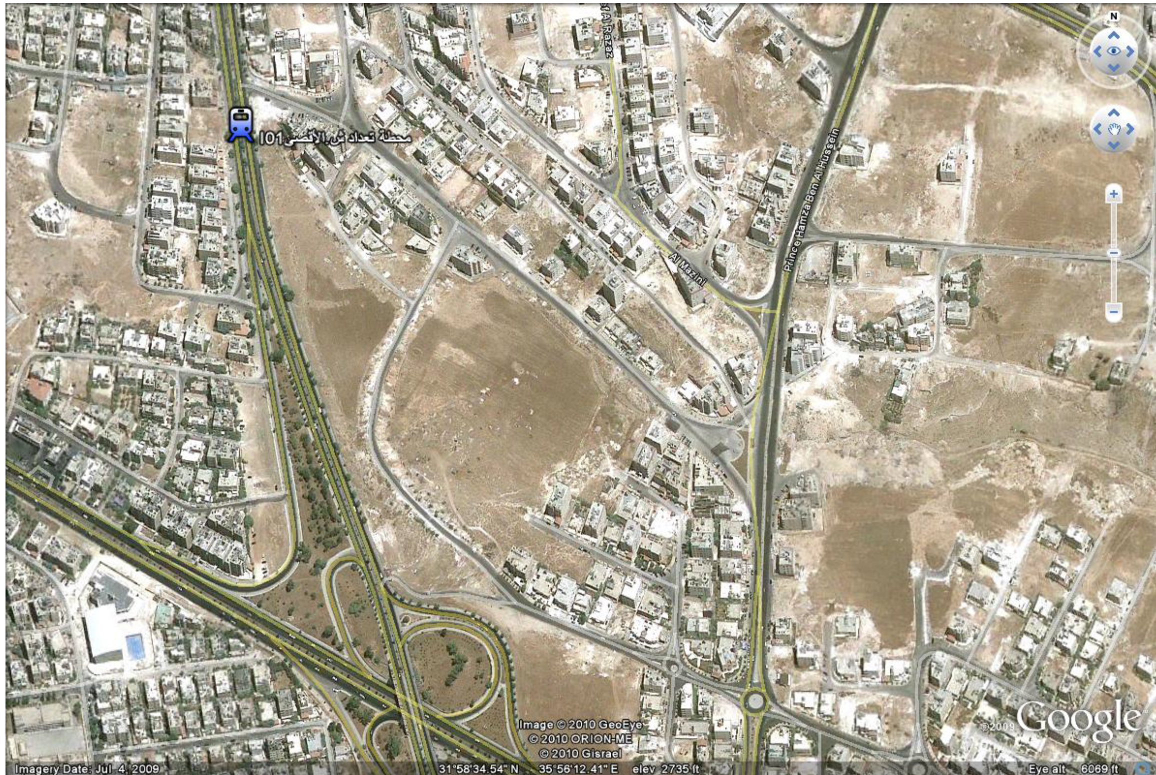


Figure-2: location of study - Al-Aqsa Street [6]

Figure-2 shows the location of TRS-I01 located in Al-Aqsa Street, the multilane highway segment length is 1.40 km extended between signalized intersection in the north and interchange in the south. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-3, this segment of the highway consists of two lanes in each direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 70 km/hr.

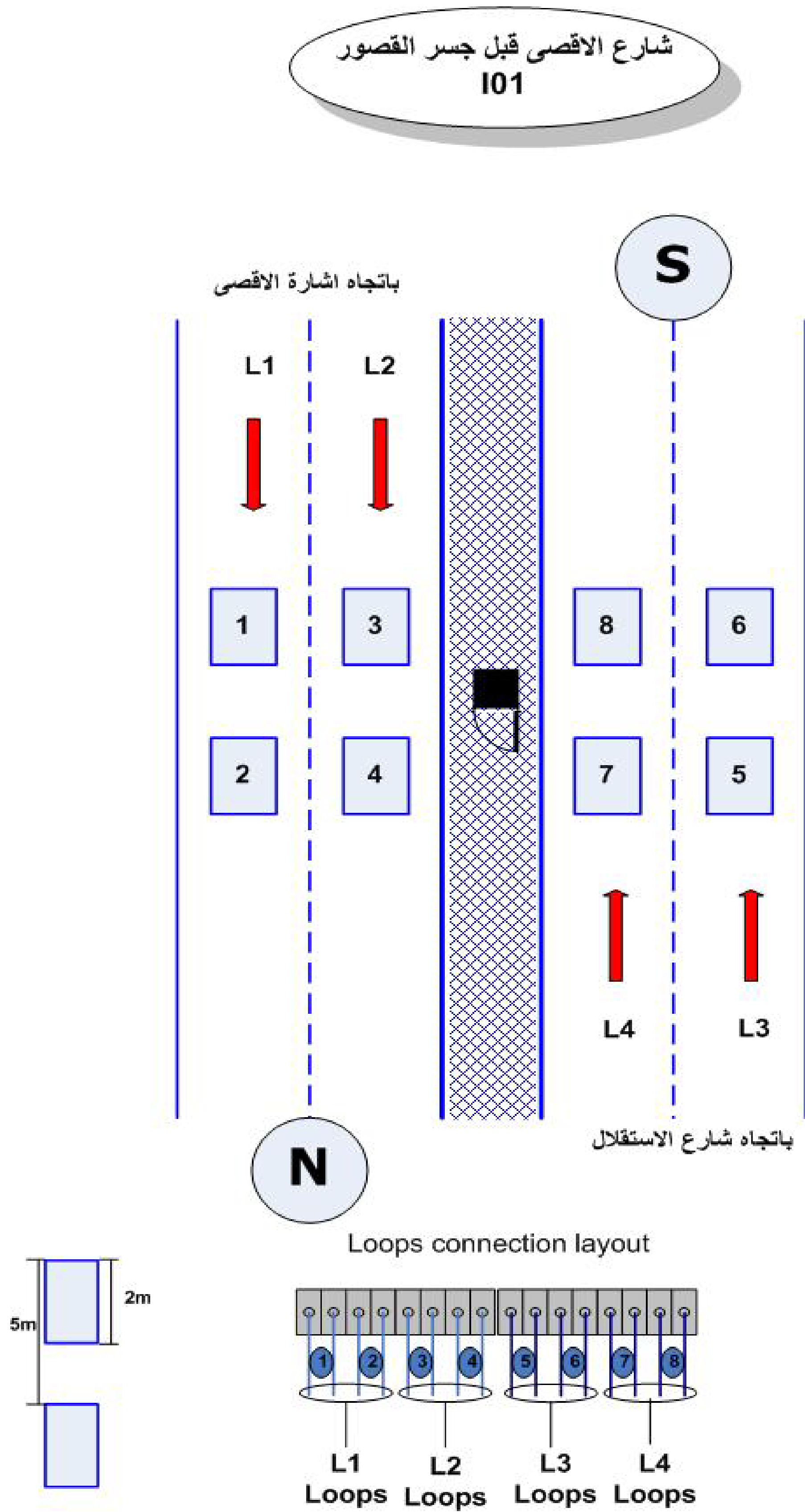


Figure-3: Station TRS-I01 layout [4]

3.1.1.2. Queen Alia Street (I03)

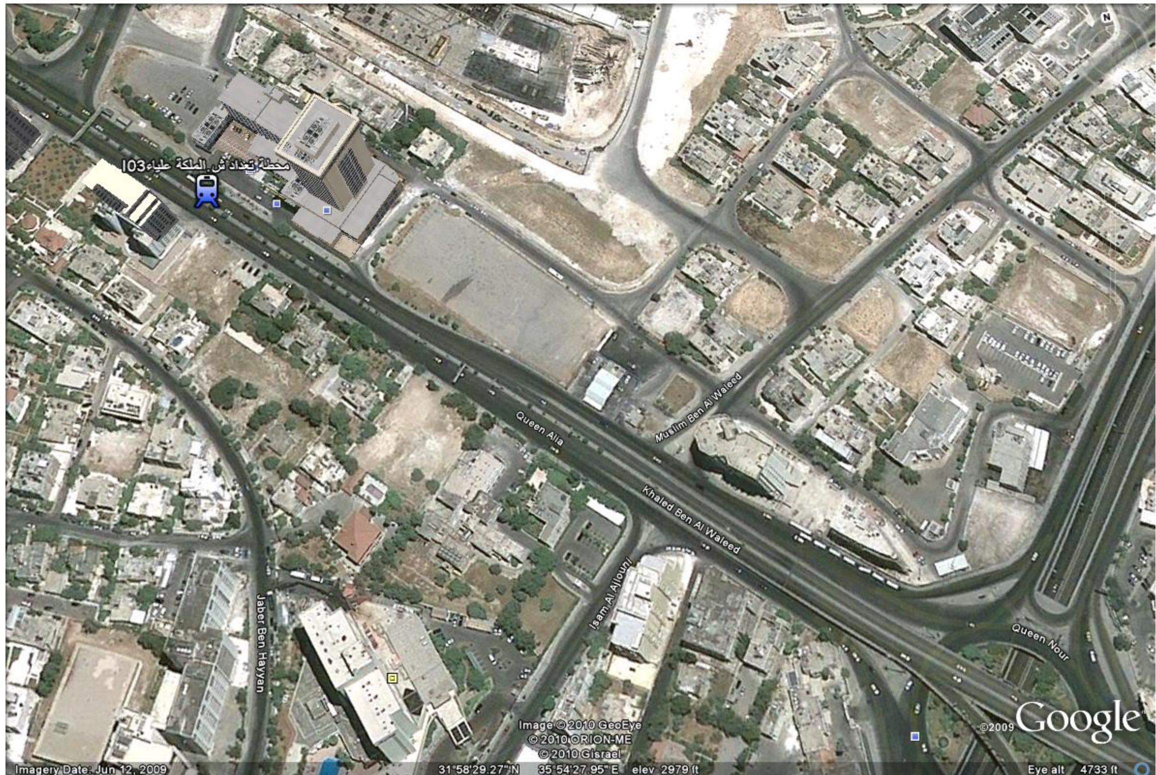


Figure-4: location of study- Queen Alia Street [6]

Figure-4 shows the location of TRS-I03 located in Queen Alia Street, the multilane highway segment length is 1.5 km extended between two interchanges. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-5, this segment of the highway consists of three lanes in each direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 70 km/hr.

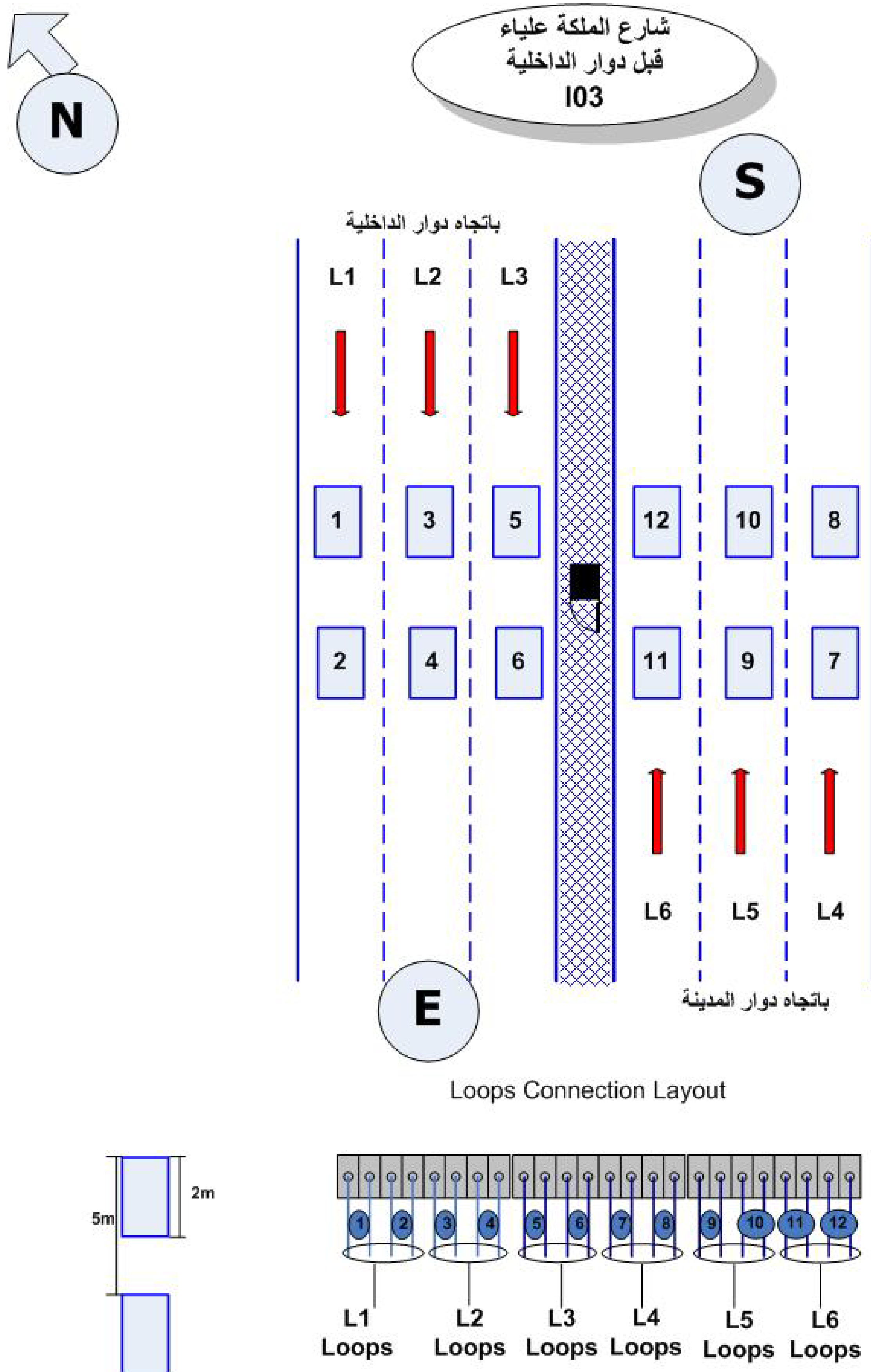


Figure-5: Station TRS-I03 layout [4]

3.1.1.3. Zahran Street (I06)

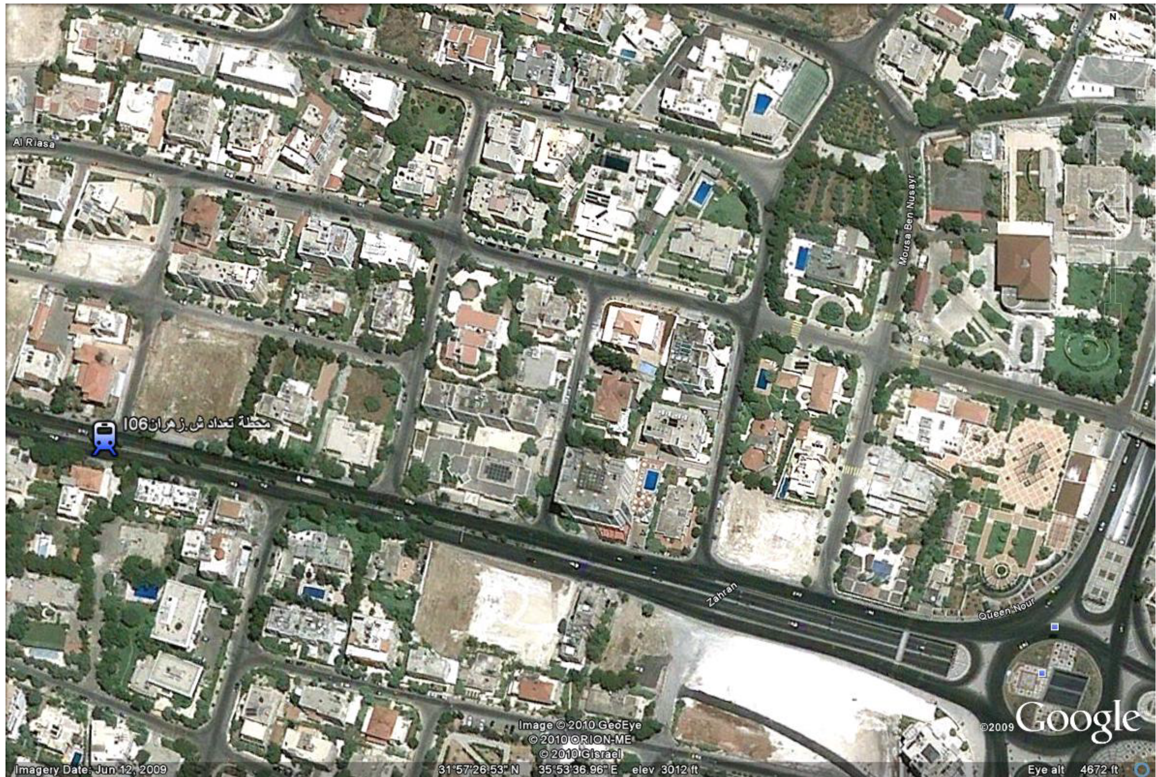


Figure-6: location of study- Zahran Street [6]

Figure-6 shows the location of TRS-I06 located in Zahran Street, the multilane highway segment length is 1.2 km extended between two roundabouts from the east to the west. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-7, this segment of the highway consists of two lanes in each direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 60 km/hr.

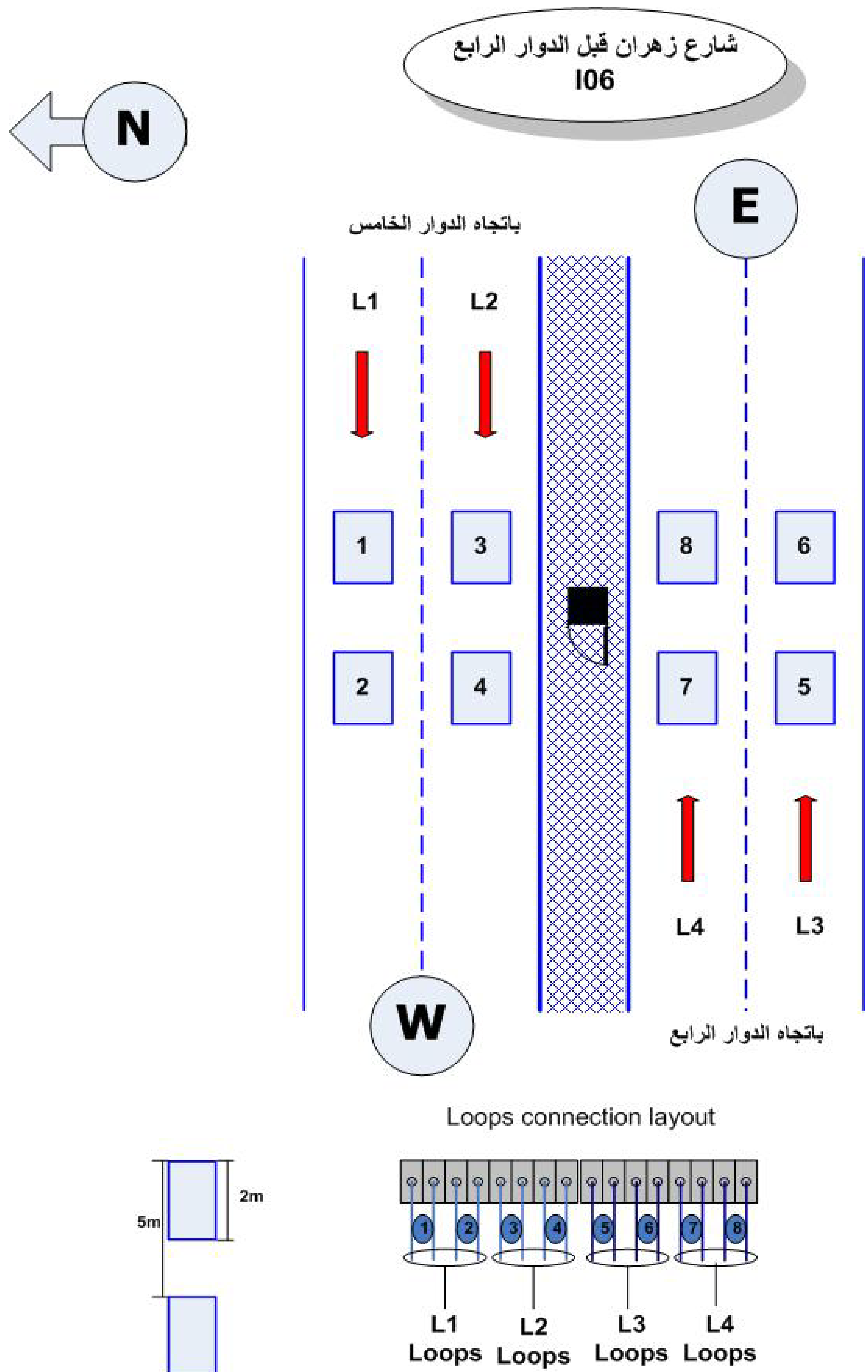


Figure-7: Station TRS-I06 layout [4]

3.1.1.4. Yarmouk Street (I11)

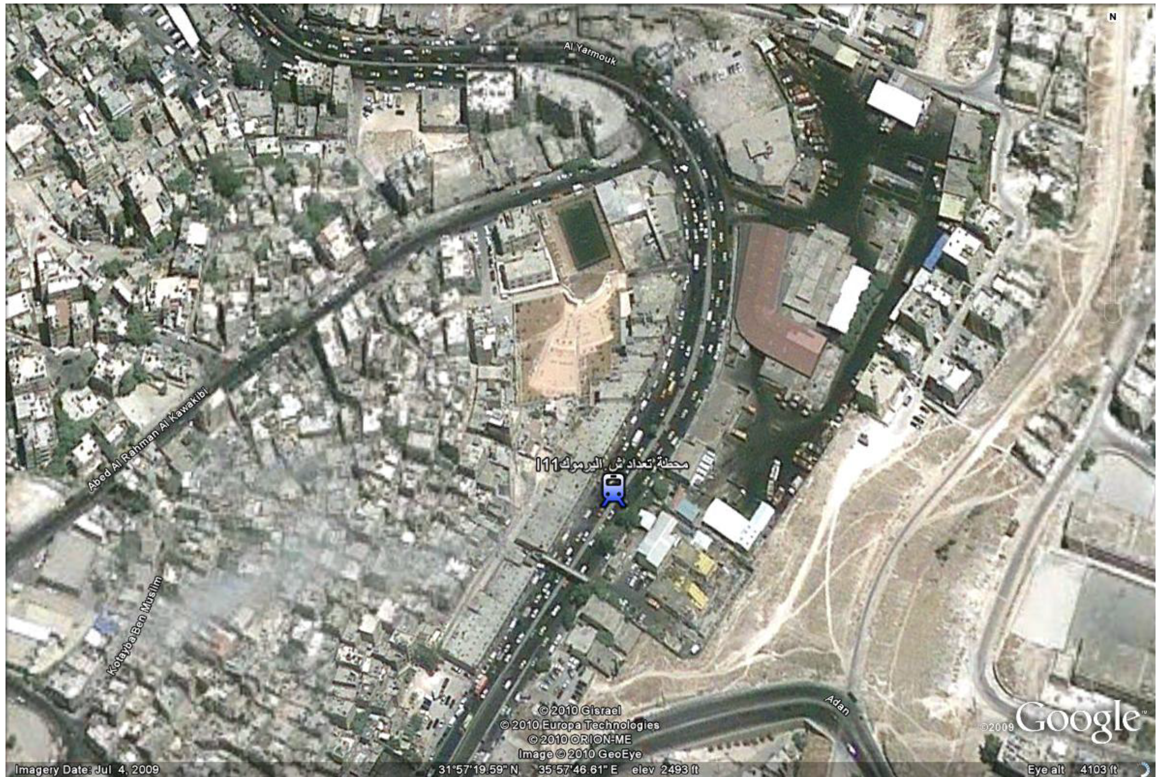


Figure-8: location of study-Yarmouk Street [6]

Figure-8 shows the location of TRS-I11 located in Yarmouk Street, the multilane highway segment length is 0.90 km extended between interchange in the north and underpass in the south. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-9, this segment of the highway consists of two lanes in one direction and three lanes on the other direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 60 km/hr.

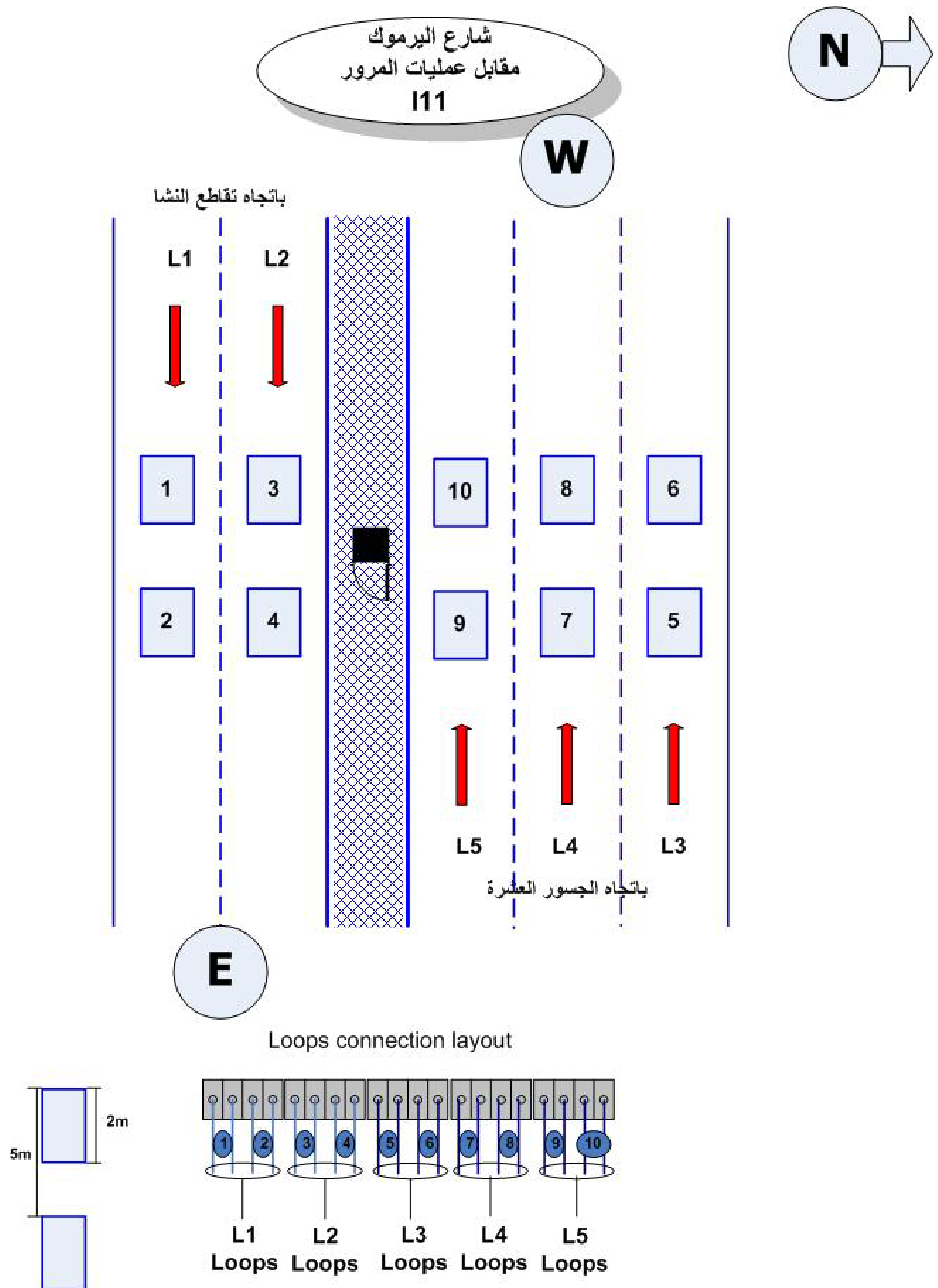


Figure-9: Station TRS-I13 layout [4]

3.1.1.5. Al-Jaish Street (I14)

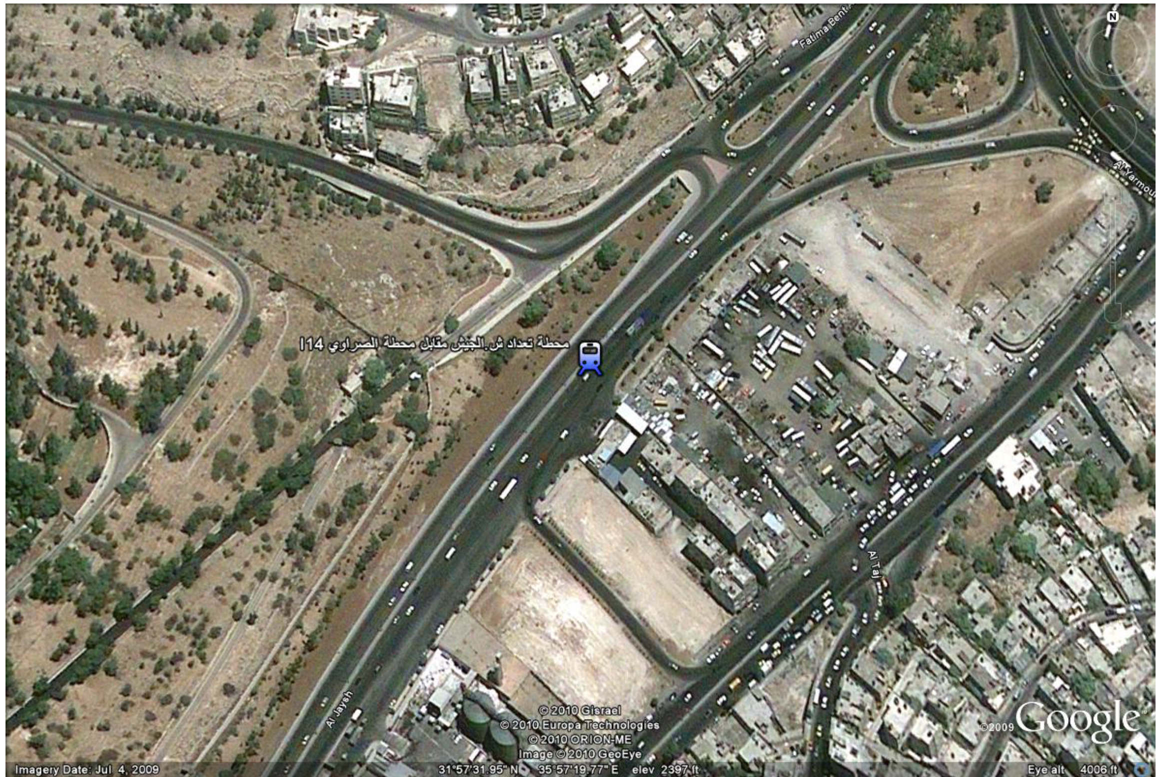


Figure-10: location of study- Al-Jaish Street [6]

Figure-10 shows the location of TRS-I14 located in Al-Jaish Street, the multilane highway segment length is 0.90 km extended between two interchanges. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-11, this segment of the highway consists of three lanes in each direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 60 km/hr.

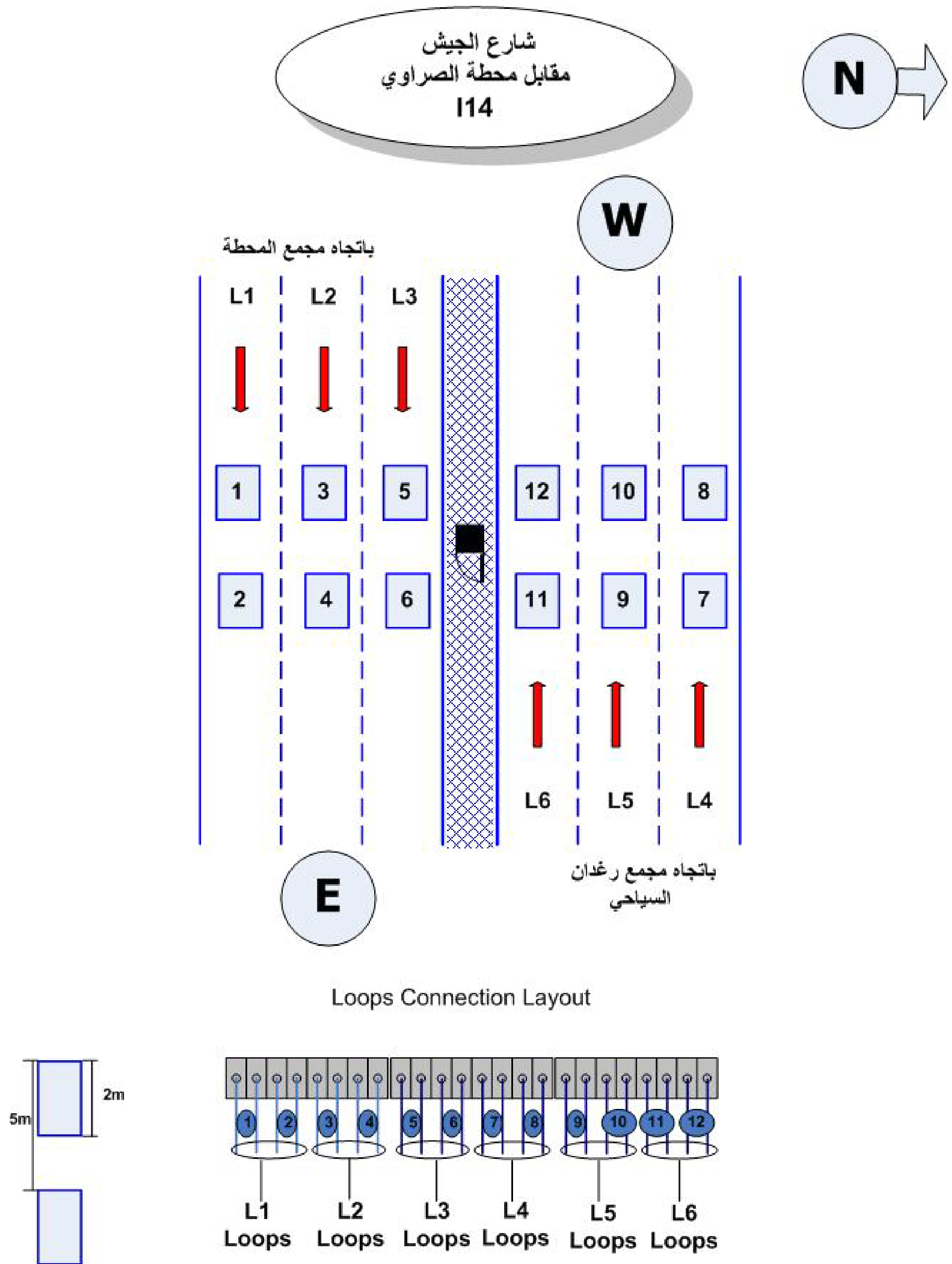


Figure-11: Station TRS-I14 layout [4]

3.1.1.6. Al-Shaheed Street (RSI11)

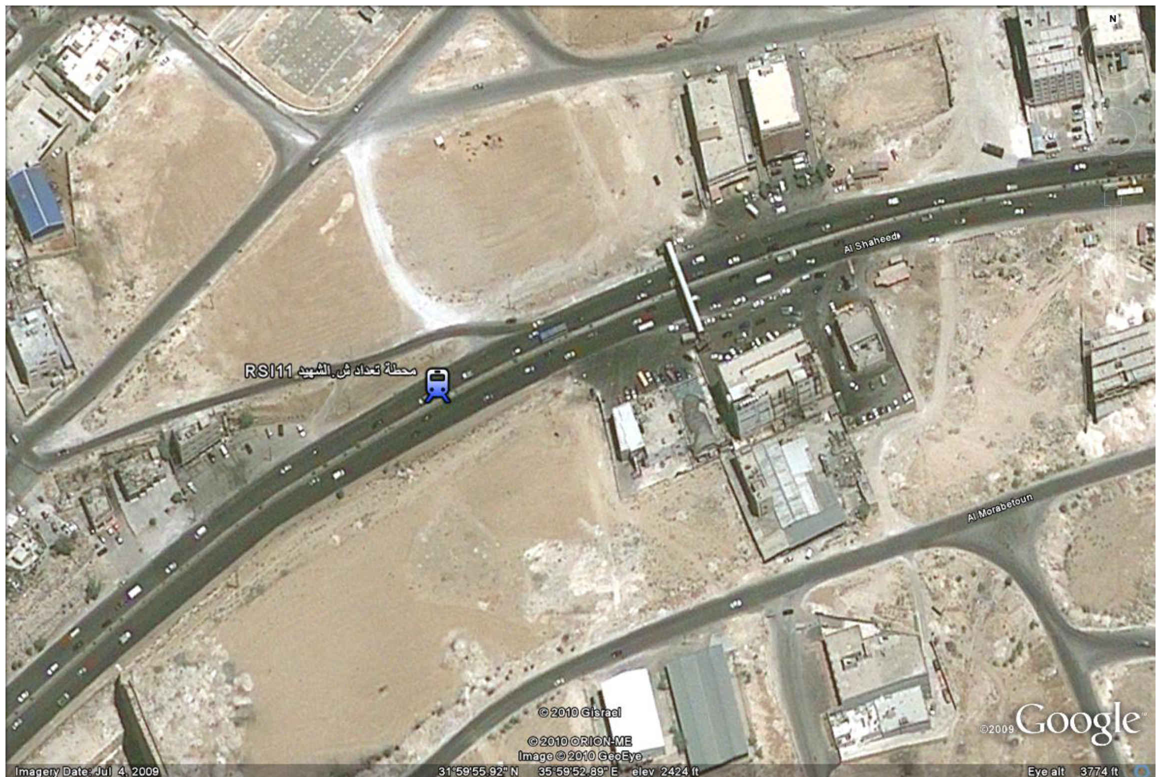


Figure-12: location of study at Al-Shaheed Street [6]

Figure-12 shows the location of TRS- RSI11 located in Al-Shaheed Street, the multilane highway segment length is 2.00 km extended between two interchanges. The TRS located at the middle of the section is to minimize the influence of the two ends. As Shown in Figure-13, this segment of the highway consists of three lanes in each direction with raised median. The surface condition of the road is good, and the street lighting available and working properly. Speed limit signs installed at the two ends and read 90 km/hr.

شارع الشهيد مقابل مخابز جواد
RSI11

N

E

باتجاه عمان

L1 L2 L3

1 3 5 12 10 8

2 4 6 11 9 7

L6 L5 L4

باتجاه الزرقاء

W

Loops Connection Layout

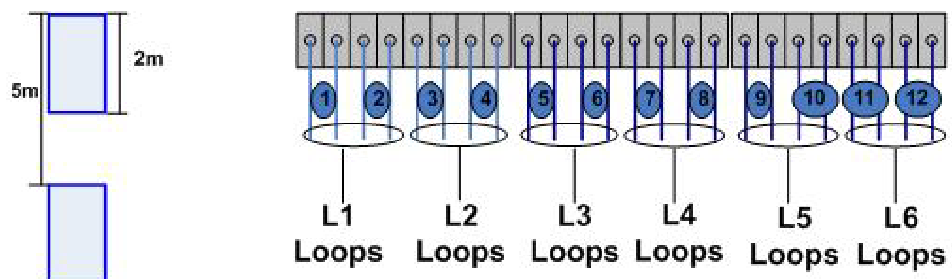


Figure-13: Station TRS- RSI11 layout [4]

3.1.2 Accidents Data

Traffic Police Department (TPD) in Amman city is responsible for recording all traffic accidents in the city. Each accident record is filled on site by an experienced authorized person. A sample of accident record is shown in Figure-14.

المملكة الأردنية الهاشمية

مديرية الأمن العام

تقرير مخطط حادث مروري/اضرار مادية

معلومات الحادث من الطريق

** معلومات المركبة رقم ( ) في مخطط الحادث

** معلومات المركبة رقم ( ) في مخطط الحادث

معلومات عن سائق المركبة أعلاه

معلومات عن سائق المركبة أعلاه

** تحديد مسؤولية الحادث **

** تحديد مسؤولية الحادث **

الرسم التخطيطي للحادث

Figure-14: A Sample of Accident record Traffic Police Department

As shown in the accident data sheet in Figure-14, the following data were collected:

- Date and time of accident,
- Street name,
- Accident location and direction (coordinates), and
- Accident type (Injuries and/or PDO)

Access permission for accidents database released upon official communication between Jordan University and the TPD. All data were classified during the study period and according to the studied arterials.

3.1.3 Highway Geometric Data

Google earth was used to determine the segment length, number of access roads and general view of the site condition for each studied road. Site visits were conducted to check the accuracy of these data along with getting sectional measurement and surface condition evaluation. Table-3 lists these measurements.

Table-3: Geometrical details of the selected sites

Road Name	TRS	Segment Length (Km)	Average Lane width (m)	Lateral clearance (m)	Number of Access roads (per kilometer)
Al-Aqsa	I01	1.40	3.25	0.50 / 0.50	1
Queen Alia	I03	1.50	2.7	0.50 / 0.50	2
Zahran	I06	1.20	3.4	0.50 / 0.50	8
Yarmouk	I11	0.90	3.45	0.50 / 0.50	5
Jaish	I14	0.90	3.35	0.50 / 0.50	2
Shaheed	RSI11	2.00	3.2	0.50 / 0.50	4

3. 2 Level of Service Calculation Method

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, maneuverability, and delay. The level of service of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst. The level of service (LOS) calculation methods are found in the HCM 2000 for different types of highway facilities such as: freeways, multilane highways, two-lane highways, and signalized intersections.

The level of service criteria for multilane highways is similar to the criteria for freeways. The specific criterion from the HCM is presented in Figure-15 for multilane highway.

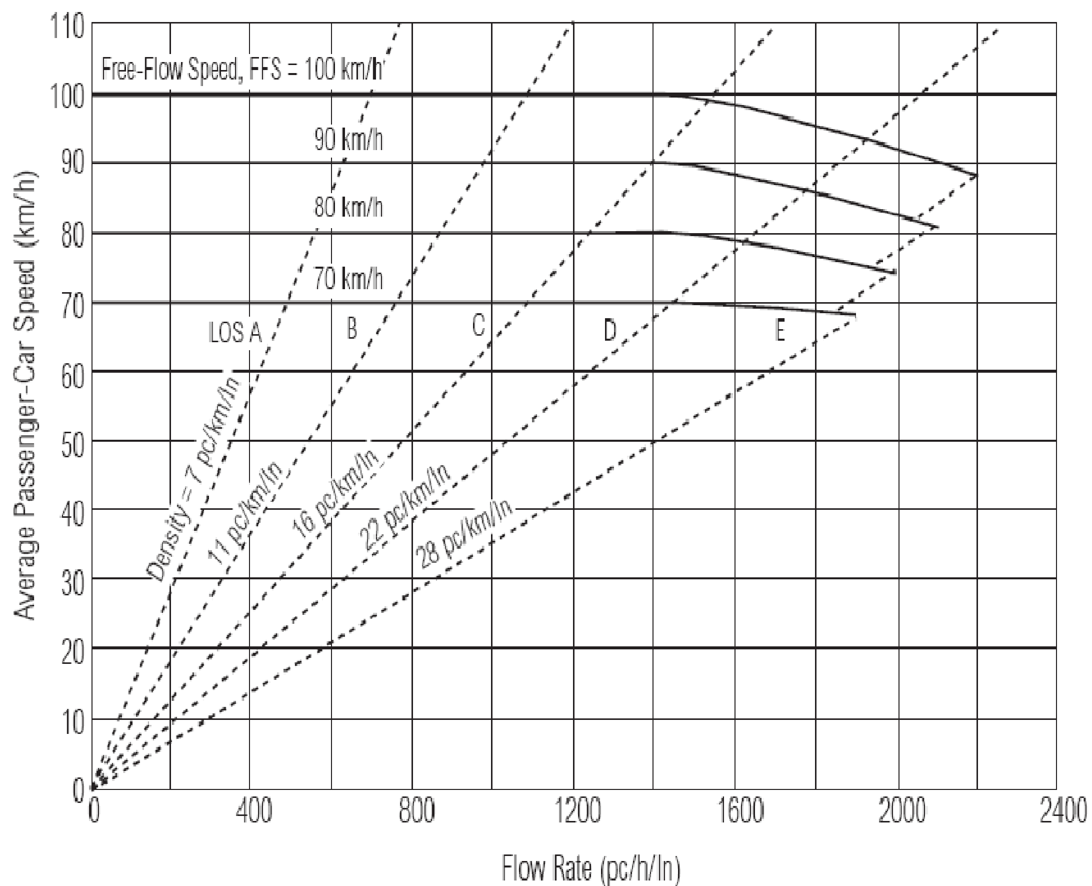


Figure-15: Speed flow curves with LOS criteria for Multilane Highway[12]

3.2.1 Determining LOS

Using HCM procedure the LOS on a multilane highway can be determined directly from Figure-15 on the basis of the FFS and the service flow rate (Vp) in pc/h/ln. As follows:

- Step1. Define and segment the highway as appropriate.
- Step 2. On the basis of the measured or estimated FFS, construct an appropriate speed-flow curve of the same shape as the typical curves shown in Figure-15. The curve should intercept the y-axis at the measured or estimated FFS.
- Step 3. Based on the flow rate V_p, read up to the FFS curve identified in Step 2 and determine the average passenger-car speed and LOS corresponding to that point.
- Step 4. Determine the density of flow according to the following Equation:

$$D = \frac{V_p}{S}$$

Where

D = density (pc/km/ln),

V_p = flow rate (pc/h/ln), and

S = average passenger-car travel speed (km/h).

The LOS also can be determined by comparing the computed density with the density ranges provided in Figure-15.

3.2.2 Segmenting The Highway

The procedures described in the HCM 2000 are best applied to homogeneous segments of roadway, for which the variables affecting travel speeds are constant. Therefore, it is often necessary for the analyst to divide a section of highway into separate segments for analysis. The following conditions generally necessitate segmenting the highway:

- A change in the basic number of travel lanes along the highway,
- A change in the median treatment along the highway,
- A change of grade of 2 percent or more or a constant upgrade over 1220 m,
- The presence of a traffic signal or a stop sign along the multilane highway,
- A significant change in the density of access points,
- A change in speed limits, and
- The presence of a bottleneck condition.

In general, when segmenting a highway for analysis, the minimum length of a study segment should be 760 m. Also, the limit of study segments should be no closer than 0.4 km to a signalized intersection. The procedures in this chapter are based on average conditions observed over an extended highway segment with generally consistent physical characteristics.

3.2.3 Computational Steps

The free flow speed was calculated based on the average recorded speed during traffic flow rate below 1300 pc/hr/lane. The results are listed in Table-4.

Table-4: The free flow speed

Street name	FFS (km/hr)
Al-Aqsa Street	76.9
Queen Alia Street	71.97
Zahran Street	70.71
Al-Yarmouk Street	70.23
Al-Jaish Street	80.01
Al-Shaheed Street	80.6

The multilane highways worksheet for computations is shown in Figure-16. For all applications, the analysts provide the required general information and site information.

MULTILANE HIGHWAYS WORKSHEET

Average Passenger-Car Speed (km/h): 40, 50, 60, 70, 80, 90, 100, 110
Flow Rate (pc/h/ln): 0, 400, 800, 1200, 1600, 2000, 2400
Free-Flow Speed 100 km/h, 90 km/h, 80 km/h, 70 km/h
LOS A, B, C, D, E
7 pc/km/ln, 11 pc/km/ln, 16 pc/km/ln, 22 pc/km/ln, 28 pc/km/ln

Application	Input	Output
Operational (LOS)	FFS, N, v_p	LOS, S, D
Design (N)	FFS, LOS, v_p	N, S, D
Design (v_p)	FFS, LOS, N	v_p, S, D
Planning (LOS)	FFS, N, AADT	LOS, S, D
Planning (N)	FFS, LOS, AADT	N, S, D
Planning (v_p)	FFS, LOS, N	v_p, S, D

General Information

Analyst ______
Agency or Company ______
Date Performed ______
Analysis Time Period ______

Site Information

Highway/Direction of Travel ______
From/To ______
Jurisdiction ______
Analysis Year ______

❑ Operational (LOS) ❑ Design (N) ❑ Design (v_p) ❑ Planning (LOS) ❑ Planning (N) ❑ Planning (v_p)

Flow Inputs

Volume, V ______ veh/h
Annual avg. daily traffic, AADT ______ veh/day
Peak-hour proportion of AADT, K ______
Peak-hour direction proportion, D ______
DDHV AADT * K * D ______ veh/h
Driver type
❑ Commuter/Weekday ❑ Recreational/Weekend

Peak-hour factor, PHF ______
% Trucks and buses, P_T ______
% RVs, P_R ______
General terrain
❑ Level ❑ Rolling ❑ Mountainous
Grade: Length ______ km Up/Down ______ %
Number of lanes ______

Calculate Flow Adjustments

f_p ______
E_T ______
E_R ______
f_{HV} $\frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$ ______

Speed Inputs

Lane width, LW ______ m
Total lateral clearance, TLC ______ m
Access points, A ______ A/km
Median type, M ❑ Undivided ❑ Divided
FFS (measured) ______ km/h
Base free-flow Speed, BFFS ______ km/h

Calculate Speed Adjustments and FFS

f_{LW} ______ km/h
f_{LC} ______ km/h
f_A ______ km/h
f_M ______ km/h
FFS $BFFS - f_{LW} - f_{LC} - f_A - f_M$ ______ km/h

Operational, Planning (LOS); Design, Planning (v_p)

Operational (LOS) or Planning (LOS)
v_p $\frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ ______ pc/h/ln
S ______ km/h
D v_p/S ______ pc/km/ln
LOS ______

Design (v_p) or Planning (v_p)
LOS ______
v_p ______ pc/h/ln
V $v_p * PHF * N * f_{HV} * f_p$ ______ veh/h
S ______ km/h
D v_p/S ______ pc/km/ln

Design, Planning (N)

Design (N) or Planning (N) 1st Iteration
N ______ assumed
v_p $\frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ ______ pc/h/ln
LOS ______

Design (N) or Planning (N) 2nd Iteration
N ______ assumed
v_p $\frac{V \text{ or } DDHV}{PHF * N * f_{HV} * f_p}$ ______ pc/h/ln
LOS ______
S ______ km/h
D v_p/S ______ pc/km/ln

Glossary

N - Number of lanes
V - Hourly volume
v_p - Flow rate
LOS - Level of service
DDHV - Directional design-hour volume
S - Speed
D - Density
FFS - Free-flow speed
BFFS - Base free-flow speed

Factor Location

E_T - Exhibit 21-8, 21-9, 21-11
E_R - Exhibit 21-8, 21-10
f_p - Page 21-11
LOS, S, FFS, v_p - Exhibit 21-2, 21-3
f_{LW} - Exhibit 21-4
f_{LC} - Exhibit 21-5
f_M - Exhibit 21-6
f_A - Exhibit 21-7

Figure-16: Multilane Highways worksheet

4. Data Presentation

4.1 Semiannual Distribution of LOS

Semiannual hourly observations of the traffic volumes and composition were collected using TRS. These data were analyzed through development of a numerical spread sheet to analyze the prevailing hourly LOS along the study period from July 2010 until the end of December 2010. The procedure introduced in HCM 2000 as shown in Figure-16 was adopted for the calculation of the level of service for multilane highway.

In the following pages, presentation of the distribution of the LOS for each road is introduced. Also the Semiannual Average Daily Traffic (ADT) is calculated to correlate the prevailing level of service with the traffic density. The term LOS occupancy rate introduced to describe the percent of time highway segment was occupied by each LOS during the six months study period.

4.1.1. Al-Aqsa Street

The semiannual ADT for Al-Aqsa Street was founded to be 51’226 veh/day with directional split value of 0.555 as calculated over the study period.

Figure-17 shows the distribution of LOS over the study period between July and December, 2010. Generally, the road has no case with LOS worse than “D”. Therefore, the demand is less than the capacity, also the ability to maneuver is only slightly restricted and the effects of minor incidents still easily absorbed.

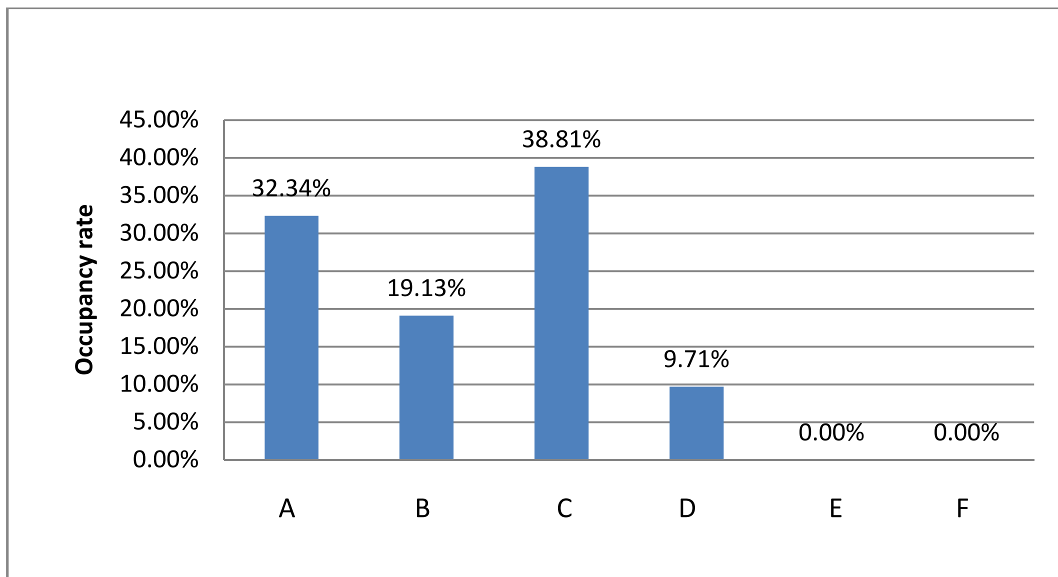


Figure 17: Al-Aqsa street semiannual LOS distribution

4.1.2. Queen Alia Street

The semiannual ADT for Queen Alia Street was founded to be 178’338 veh/day with directional split value of 0.543 as calculated over the study period.

Figure-18 shows the distribution of LOS over the study period between July and December, 2010. Generally, the street LOS “E” and “F” extended for 57% of the time; therefore, the demand is greater than the capacity, also any disruption causes queuing.

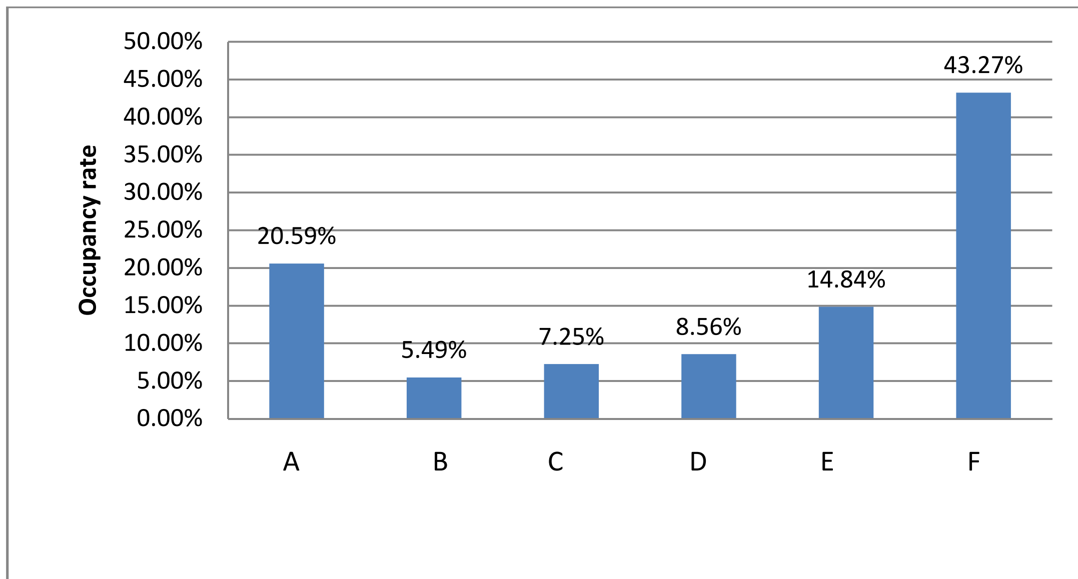


Figure 18: Queen Alia street semiannual LOS distribution

4.1.3. Zahran Street

The semiannual ADT for Zahran Street was founded to be 121’503 veh/day with directional split value of 0.527 as calculated over the study period.

Figure-19 shows the distribution of LOS over the study period between July and December, 2010. Generally, the street LOS “E” and “F” extended for 56% of the time; therefore, the demand is greater than the capacity, also any disruption causes queuing.

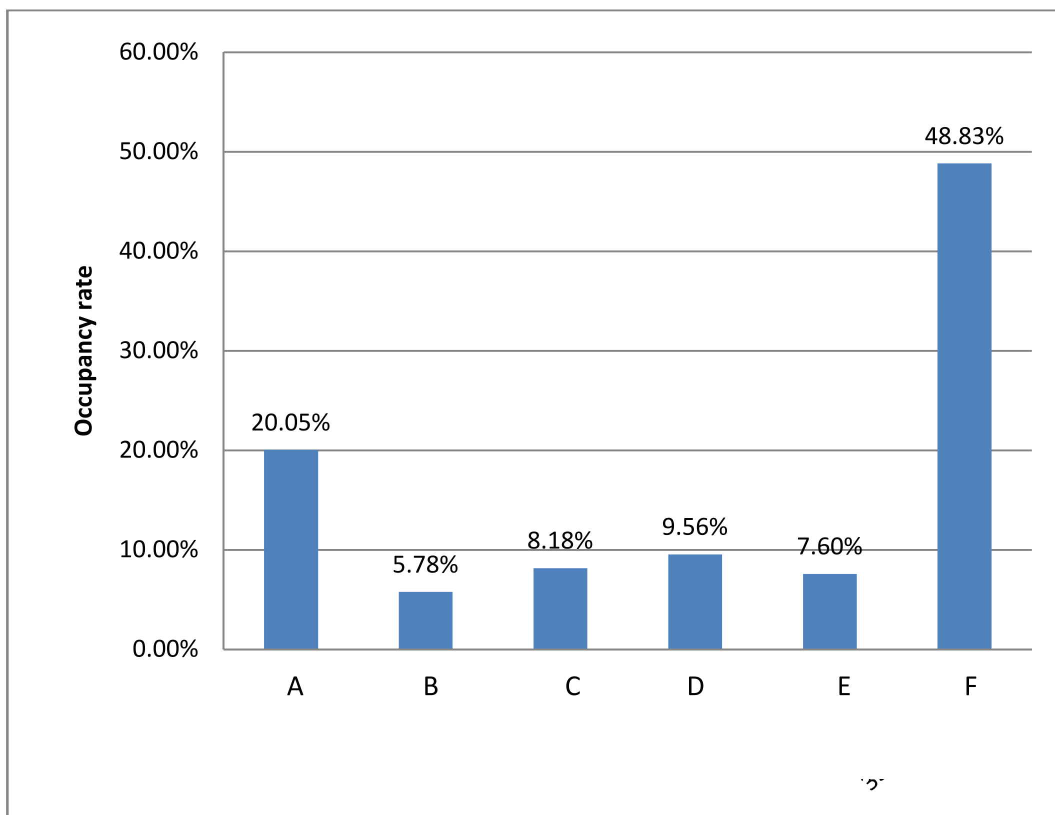


Figure 19: Zahran street semiannual LOS distribution

4.1.4. Al-Yarmouk Street

The semiannual ADT for Al-Yarmouk Street was founded to be 133’947 veh/day with directional split value of 0.556 as calculated over the study period.

Figure-20 shows the distribution of LOS over the study period between July and December, 2010. Generally, the street LOS “E” and “F” extended for 56% of the time; therefore, the demand is greater than the capacity, also any disruption causes queuing.

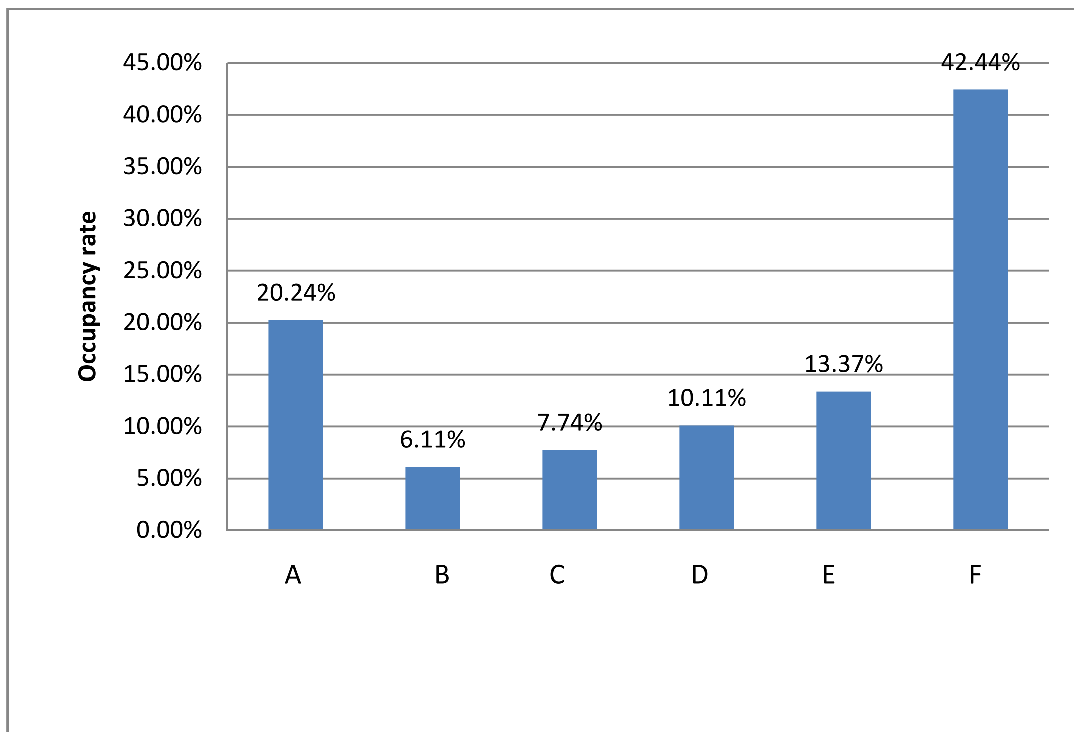


Figure 20: Al-Yarmouk street semiannual LOS distribution

4.1.5. Al-Jaish Street

The semiannual ADT for Al-Jaish Street was founded to be 99’263 veh/day with directional split value of 0.556 as calculated over the study period.

Figure-21 shows the distribution of LOS over the study period between July and December, 2010. Generally, the street LOS “E” and “F” extended for 23% of the time; while about 30% of the time LOS “D” is the prevailing condition; therefore, speeds decline slightly with increasing flows and freedom to maneuver is more noticeably limited.

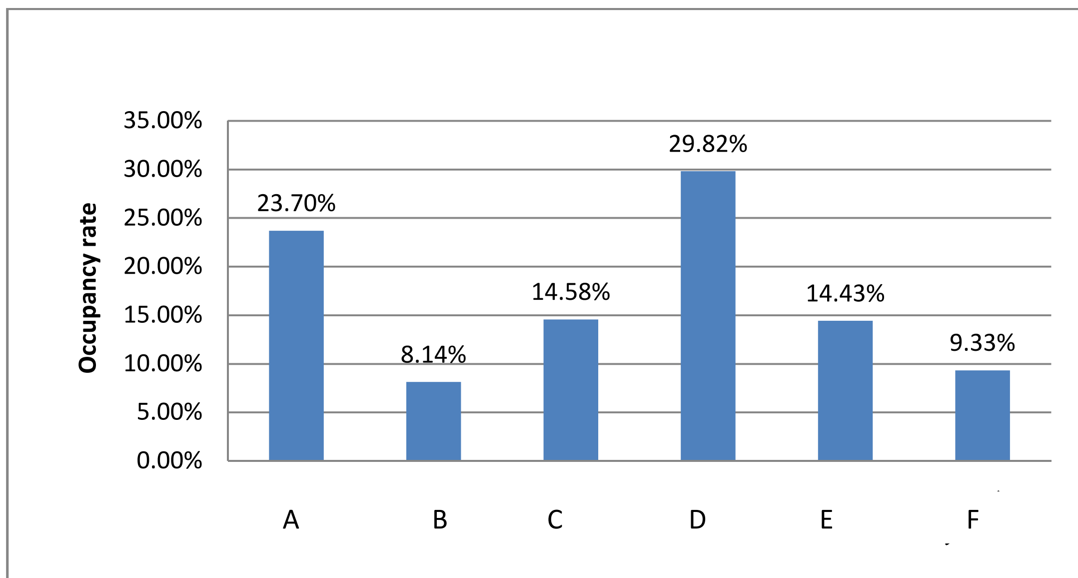


Figure 21: Al-Jaish street semiannual LOS distribution

4.1.6. Al-Shaheed Street

The semiannual ADT for Al-Shaheed Street was founded to be 132’635 veh/day with directional split value of 0.533 as calculated over the study period.

Figure-22 shows the distribution of LOS over the study period between July and December, 2010. Generally, the street has minor observations for LOS greater than “D”; therefore, the demand in general is less than the capacity, also the freedom to maneuver is more noticeably limited and queues may form behind any significant blockage.

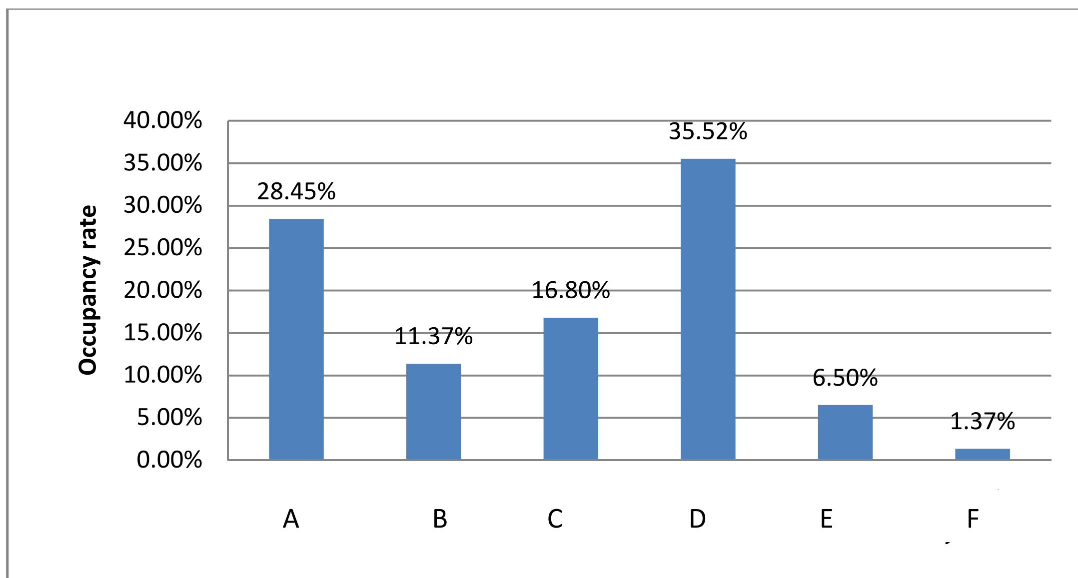


Figure 22: Al-Shaheed street semiannual LOS distribution

4.2 Semiannual total accidents distribution over LOS

As LOS gets enhanced, fewer accidents were observed; this is due to the fact that reaching “E” or “F” LOS will result in no usable gaps in the traffic stream, the operations extremely volatile, and any disruption causes queuing. These factors will increase the chance for vehicle collisions, regardless of the damage and the losses occupied in the accident.

The queue resulting from an accident on a street portion usually extended between 10 minutes to 15 minutes until the removal of the blockage. Due to the availability of specialized experts in the field of traffic accident investigations, new regulations had been issued to enforce the removal of vehicles involved in accidents immediately away from carriageway to ensure continuous traffic stream.

This process might involve minor error due to human error and due to the fact that not all traffic accident reported in police traffic department.

Throughout the following pages, the observation for each street’s accident is aggregated over prevailing LOS during the accident time as per the accident data sheet.

4.2.1 Al-Aqsa Street

According to Figure-23, while level of service “C” occurs 39% of time, about 50% of the accidents occupied with LOS “C”. Taking into consideration that the worst LOS occurred was “D’ for Al-Aqsa Street that was extended for 10% of time was involved with 21% of accidents. And no accidents were observed for LOS “A” that extended for 32% of time. This can be justified due to the free flow operations that involved with enough distance between successive vehicles, and the unrestricted ability to maneuver.

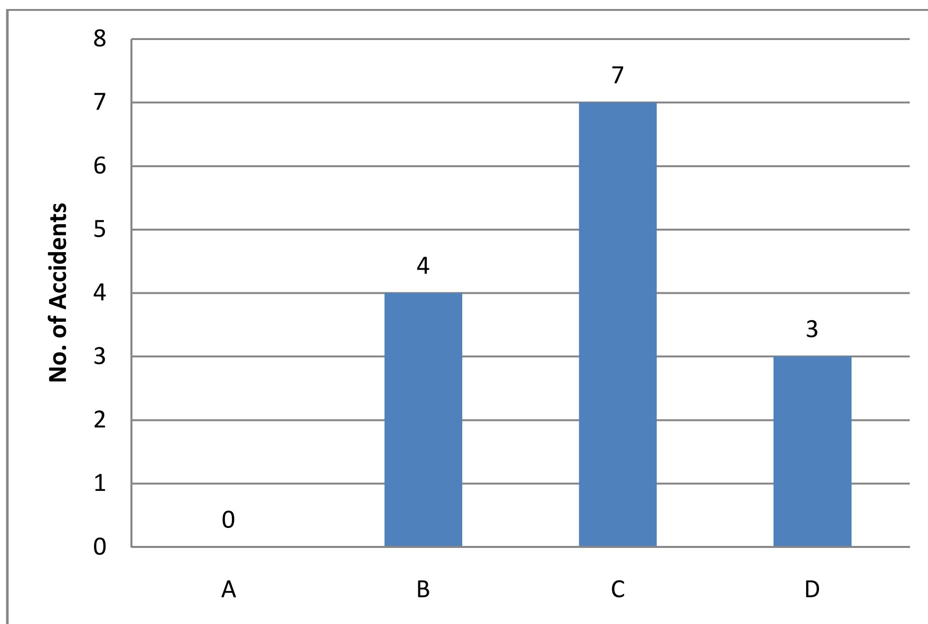


Figure 23: Al-Aqsa street semiannual accidents distribution

4.2.2 Queen Alia Street

According to Figure-24, while level of service “F” occurred for 43% of time, 74% of the accidents occupied within LOS “F”. The remaining percent of the accidents were distributed over LOS “A” to “E”. This clearly justifies the advantages of enhancing the LOS to “E” as an immediate mitigation to significantly reduce number of accidents in the Amman arterials.

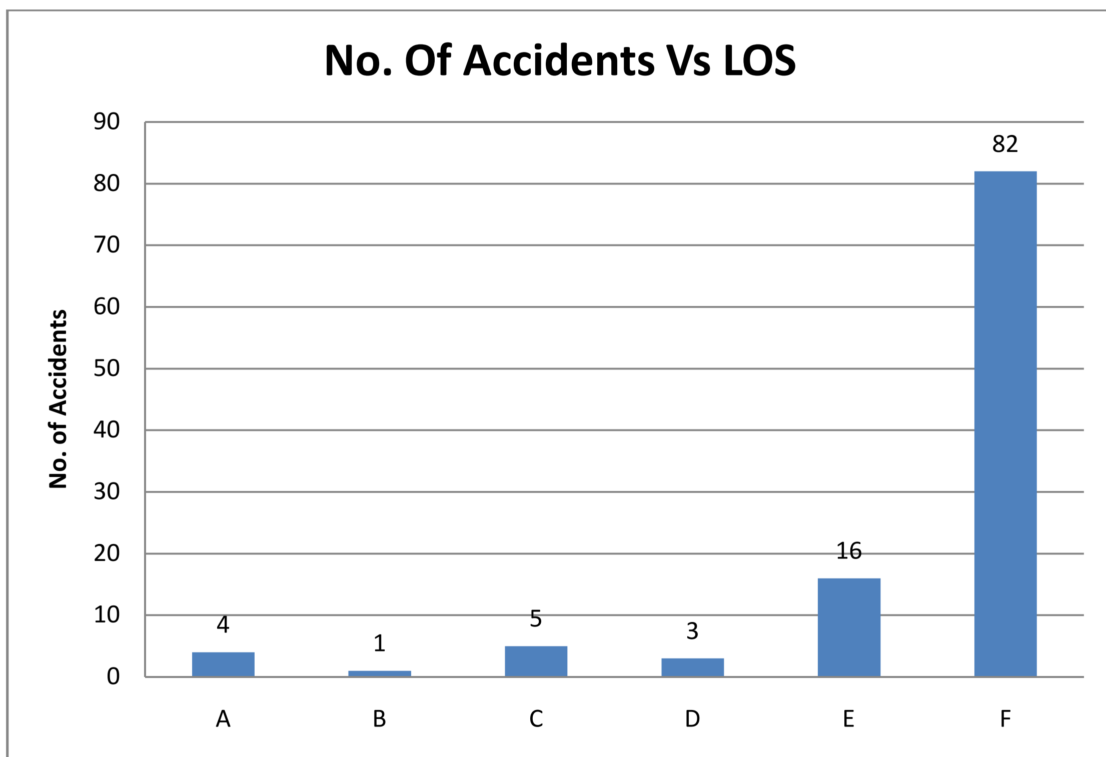


Figure 24: Queen Alia street semiannual accidents distribution

4.2.3 Zahran Street

According to Figure-25, while level of service “F” occurred for 49% of time, about 81% of the accidents occupied within LOS “F”. The remaining 19% of the accidents were distributed over LOS “A” to “E”. This clearly justifies the advantages of enhancing the LOS to “E” as an immediate mitigation to significantly reduce the number of accidents in Amman arterials.

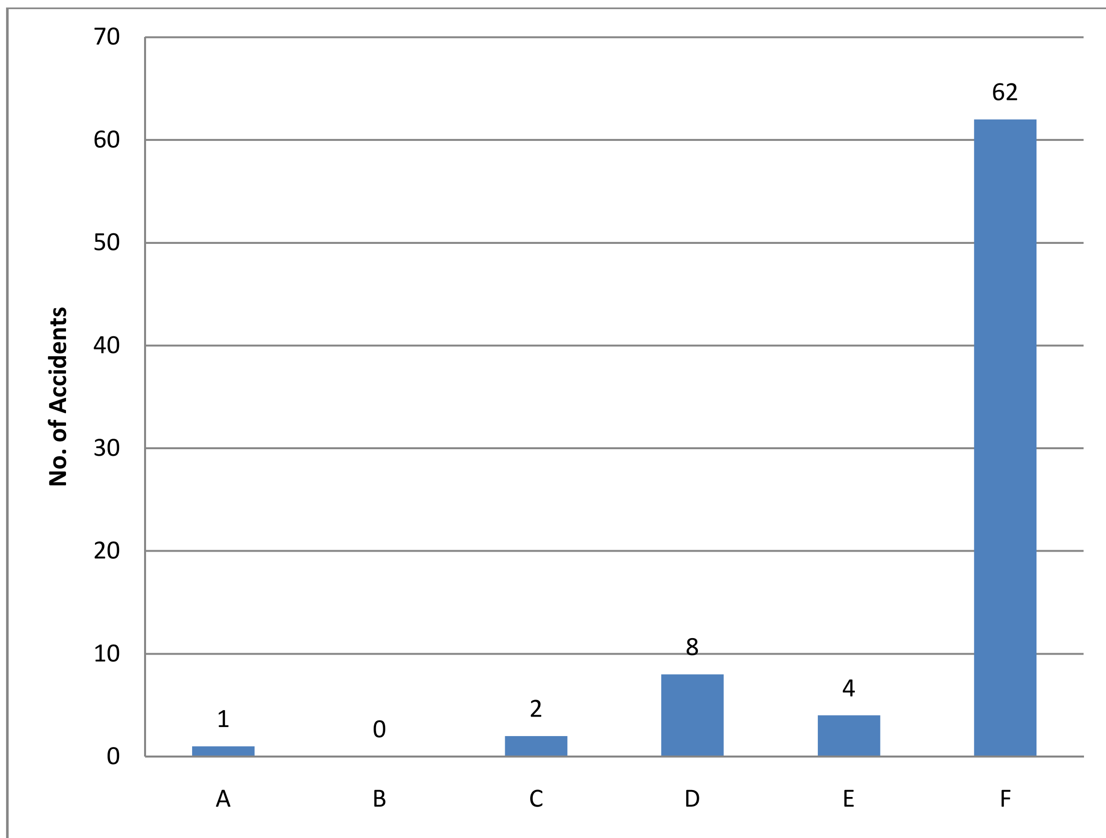


Figure 25: Zahra street semiannual accidents distribution

4.2.4 Al-Yarmouk Street

According to Figure-26, while level of service “F” occurs 43% of time, about 65% of the accidents occupied with LOS “F”. The remaining 35% of the accidents were distributed over LOS “A” to “E”. This clearly justifies the advantages of enhancing the LOS to “E” as an immediate mitigation to significantly reduce the number of accidents in Amman arterials.

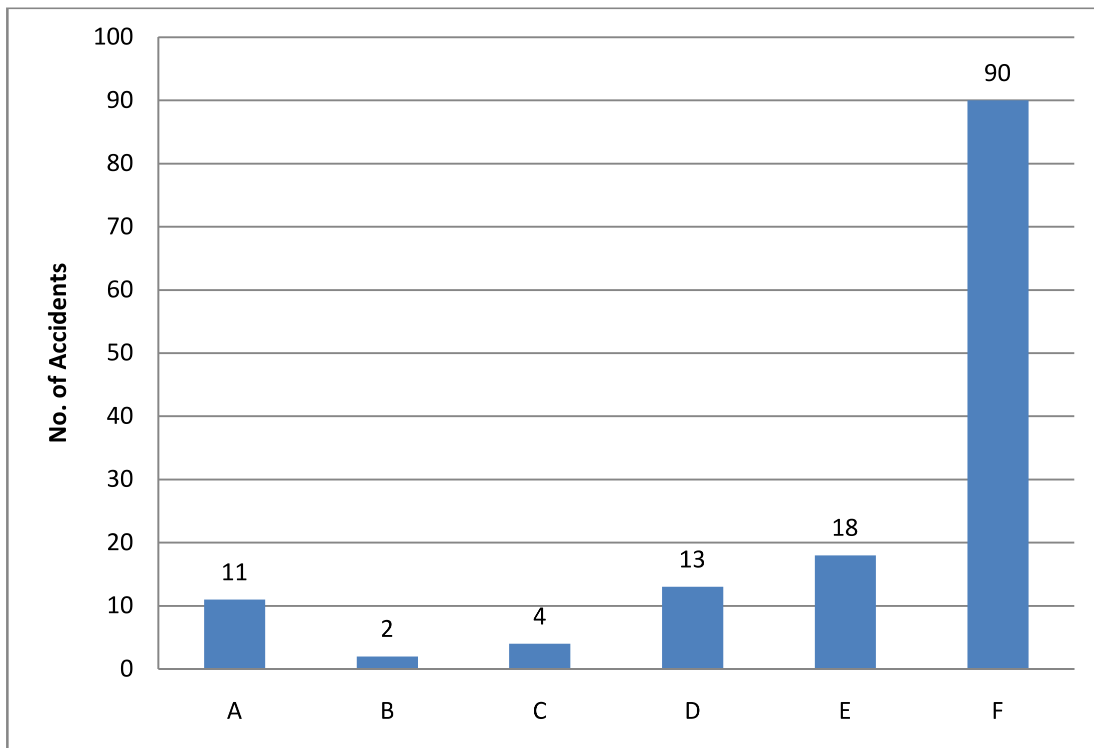


Figure 26: Al-Yarmouk Street semiannual accidents distribution

4.2.5 Al-Jaish Street

According to Figure-27, while level of service “F” occurs 9% of time, about 18% of the accidents occupied within LOS “F”. On The other hand, 73% of the accidents were distributed over LOS “D” and “E”. It is clearly indicated that no accidents occurred within LOS “A” and “B”, and only 9% of the accidents occurred within LOS “C”.

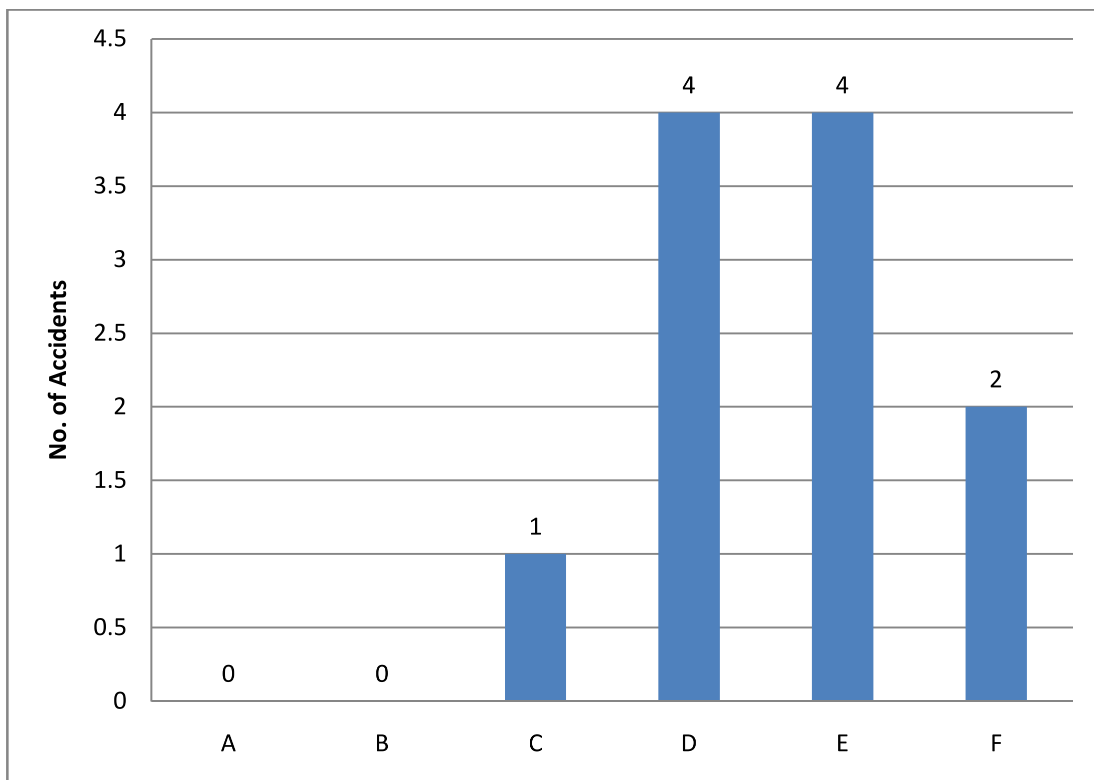


Figure 27: Al-Jaish street semiannual accidents distribution

4.2.6 Al-Shaheed Street

According to Figure-28, while level of service “D” occurs 36% of time, about 54% of the accidents occupied within LOS “D”. The remaining 46% of the accidents were distributed over LOS “A”, “B”, “C”, “E” and “F”. This flat distribution of accidents over all LOS criteria except “D” can be referred to the relatively high operating speed comparing to other streets in the study. Also, the highway section connects Amman city with Zarqa city through a relatively long trip, this is with noticeable exceeding to the speed limit.

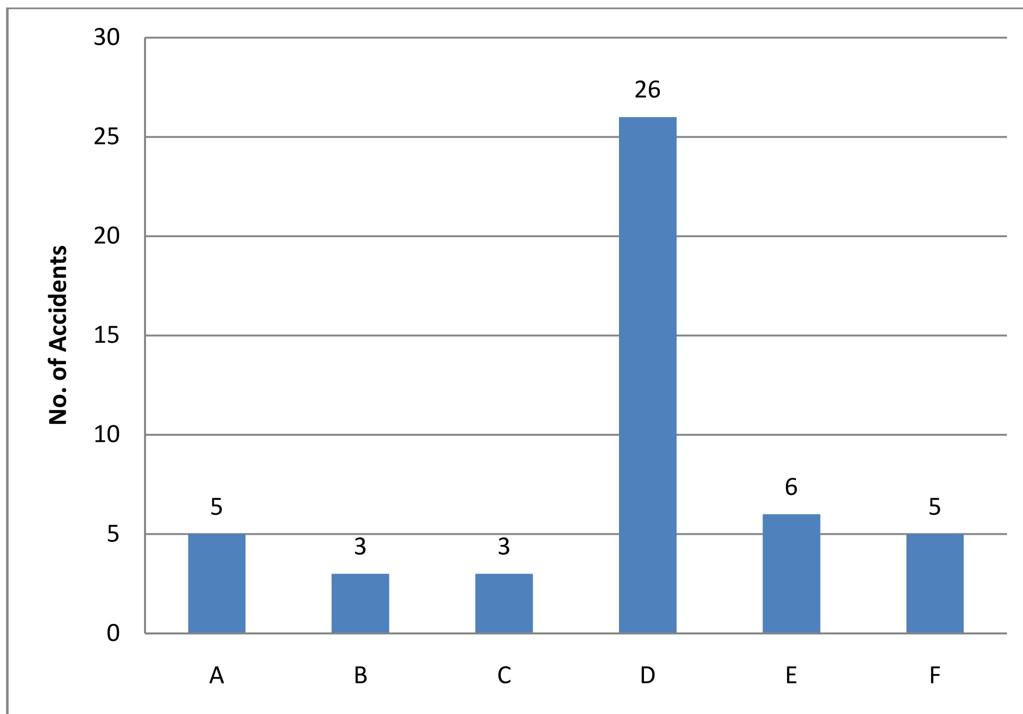


Figure 28: Al-shaheed street semiannual accidents distribution

4.3 Injury accidents semiannual distribution over LOS

This section provides information about accidents and injuries from the point of view of what LOS they occurred in. Motor vehicle accidents are an unfortunate but common occurrence. This section provides the distribution of injuries accidents along the different LOS.

The worst LOS prevailing condition contributes according to observation of the maximum percent of injuries. However, minor injuries usually are not recorded on the accident data sheet to avoid going to courts. In general, due to reduction in speed with worst LOS the number of injuries usually decreased, and the observation for Amman arterials in this study needs further investigation.

The reasons beyond presentation of the injuries in this study were to justify the needs for the implementation of proposed mitigation to enhance LOS and accordingly reduce the rate of accidents in order to save citizen life.

4.3.1 Al-Aqsa Street

Al-Aqsa Street, as shown in Figure-29, had no involvement of injury accidents along the semiannual study period between July and December, 2010. This absence of injuries along with a significant number of accidents could be referred to the fact that this street occupied with LOS equal to or better than "C" for more than 90% of time, at the same time the speed limit is 70km/hr.

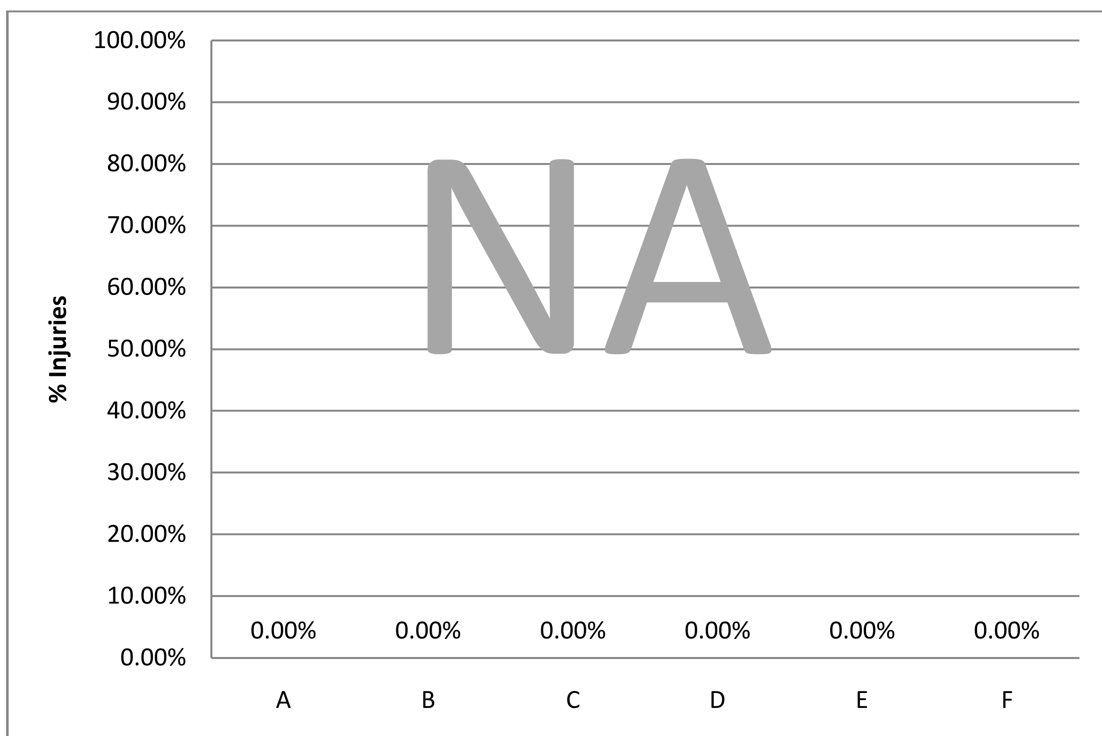


Figure 29: Al-Aqsa Street Injuries accident distribution

4.3.2 Queen Alia Street

For Queen Alia Street, as shown in Figure-30, the percent of accidents involved with injuries was 22.5% of total semiannual accidents. About 69% of these observations occur at LOS “E” and “F” that hold 88% of total accidents.

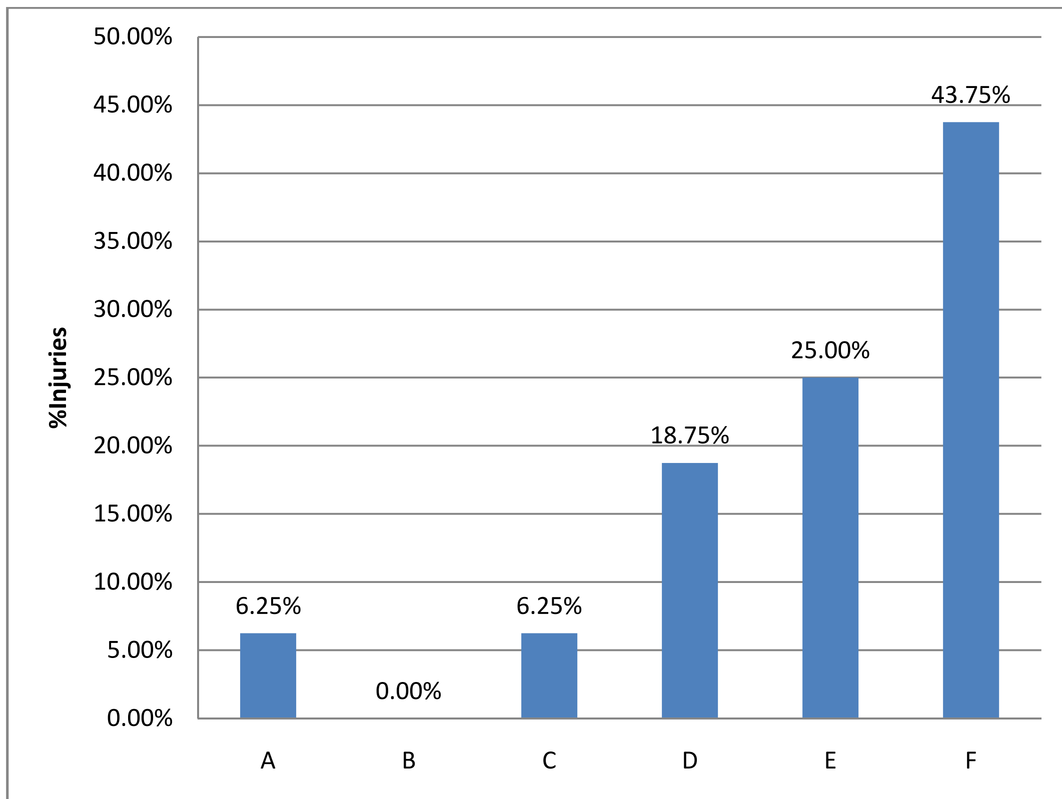


Figure 30: Queen Alia Street Injuries accident distribution

4.3.3 Zahran Street

For Zahran Street, as shown in Figure-31, the percent of accidents involved with injuries was 5% of total semiannual accidents. About 75% of these observations occur at LOS “F” that hold 80% of total accidents. The remaining 25% observations occur at LOS “D” alone.

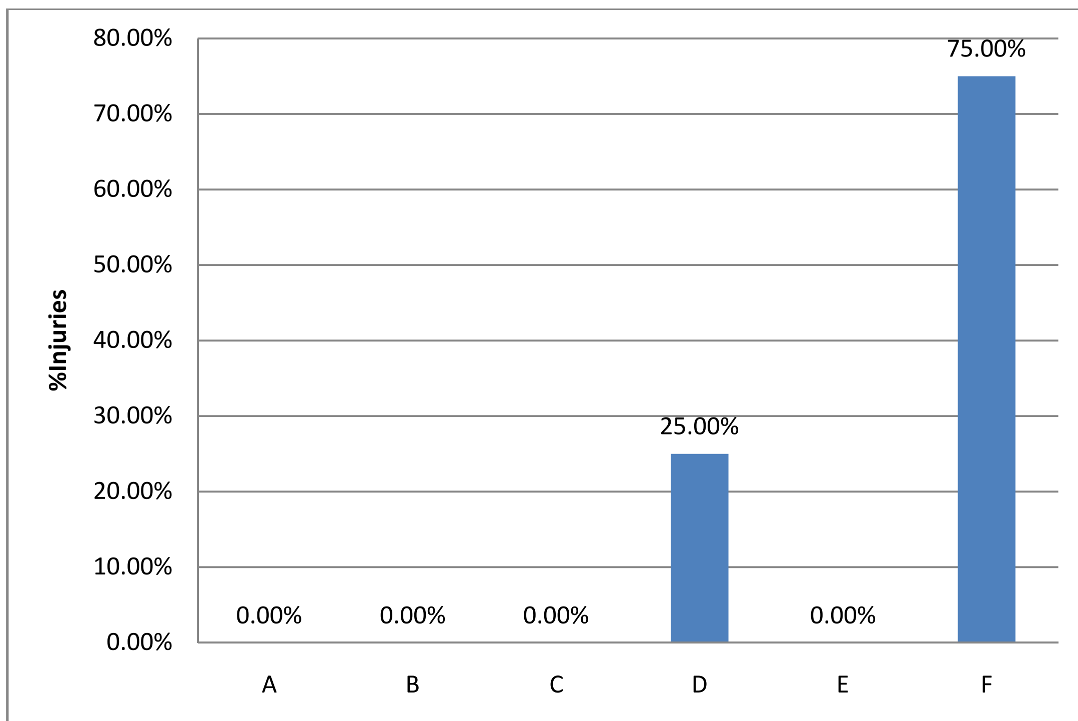


Figure 31: Zahran Street Injuries accident distribution

4.3.4 Al-Yarmouk Street

For Al-Yarmouk Street, as shown in Figure-32, the percent of accidents involved with injuries was 10% of total semiannual accidents. About 50% of these observations occur at LOS "F" that hold 65% of total accidents. The remaining observations were distributed flat over the other LOS conditions.

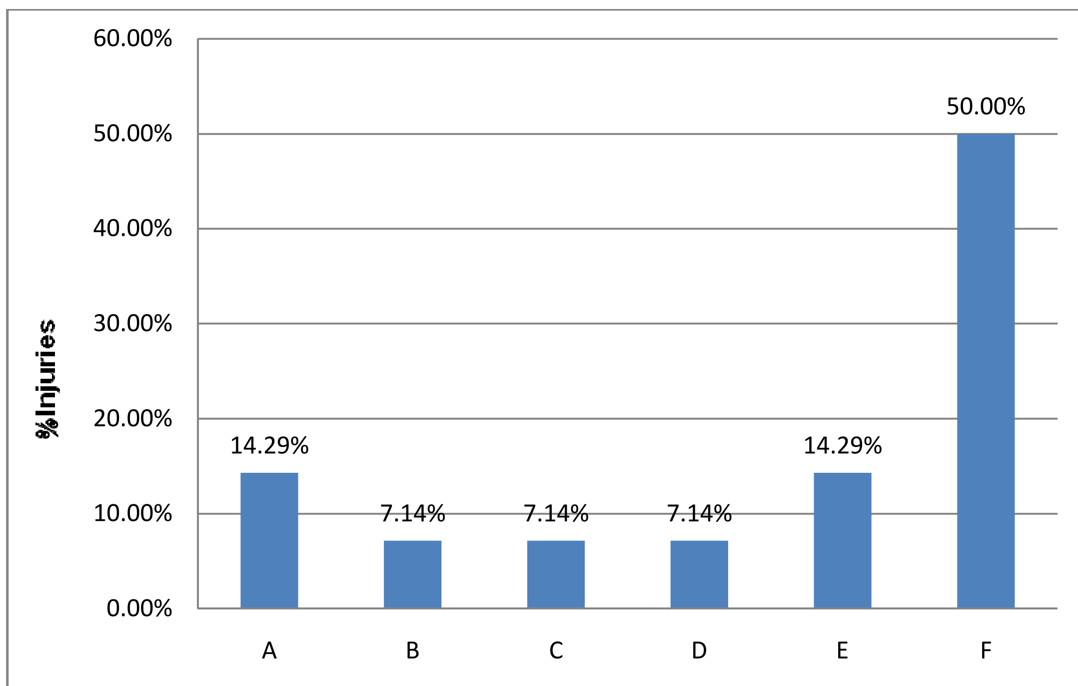


Figure 32: Al-Yarmouk Injuries accident distribution

4.3.5 Al-Jaish Street

For Al-Jaish Street, as shown in Figure-33, the percent of accidents involved with injuries was 9% of total semiannual accidents. All these observations occurred within LOS "D" that continued for less than 30% of time.

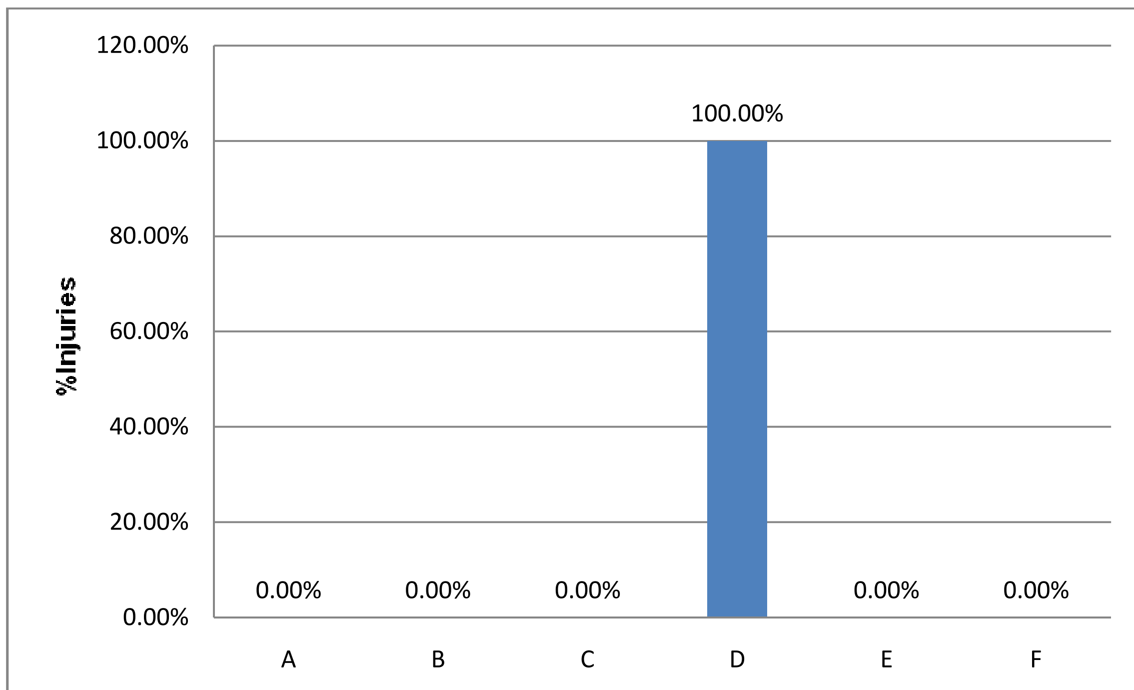


Figure 33: Al-Jaish Injuries accident distribution

4.3.6 Al-Shaheed Street

For Al-Shaheed Street, as shown in Figure-34, the percent of accidents involved with injuries was 4% of total semiannual accidents. And these were equally distributed between LOS "A" and "D". However, the total number of injury observations was two, and therefore the pattern could not be predicted accurately.

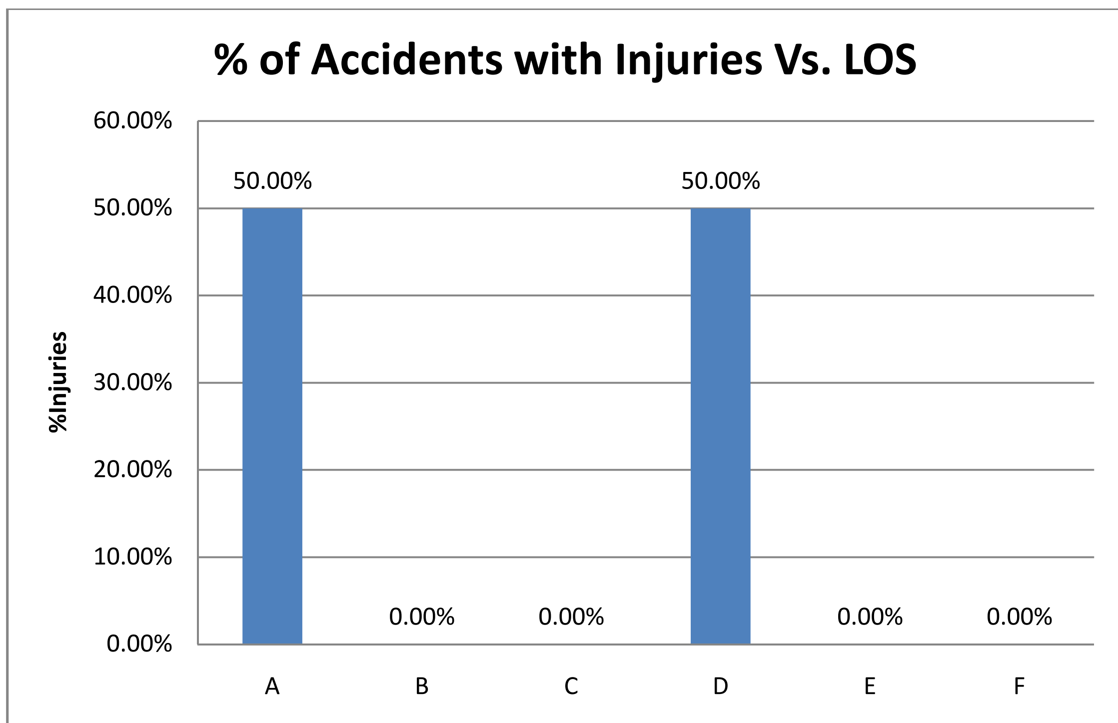


Figure 34: Al-Shaheed Injuries accident distribution

4.4 Rate of accidents distribution with LOS

For each street, the total number of operating hours under each LOS was aggregated; also the total number of accidents observed within each level of service was counted too. The rate of accidents term was introduced to account for the total number of accidents occurred within each LOS per million vehicles.

In the following pages, histograms are presented to indicate the relation between different LOS and total number of accidents. In general, it will be noted that the worst the LOS the higher the number of accidents. This was due to the increase of both horizontal and lateral friction between vehicles, and the restriction on maneuvering by drivers to avoid accidents.

There are many other factors that might affect the rate of accidents as:

1. Vehicle Failure
2. Roadway Design
3. Poor Roadway Maintenance
4. Driver Behavior

Over 95% of motor vehicle accidents (MVAs, in the USA, or Road Traffic Accidents, RTAs, in Europe) involve some degree of driver behavior combined with one of the other three factors. Most are caused by excessive speed or aggressive driver behavior due to traffic and roadway conditions. This study focuses on the traffic conditions, and road geometry.

Al-Aqsa Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-35 for Al-Aqsa Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows excellent correlation with R2 value of 0.843.

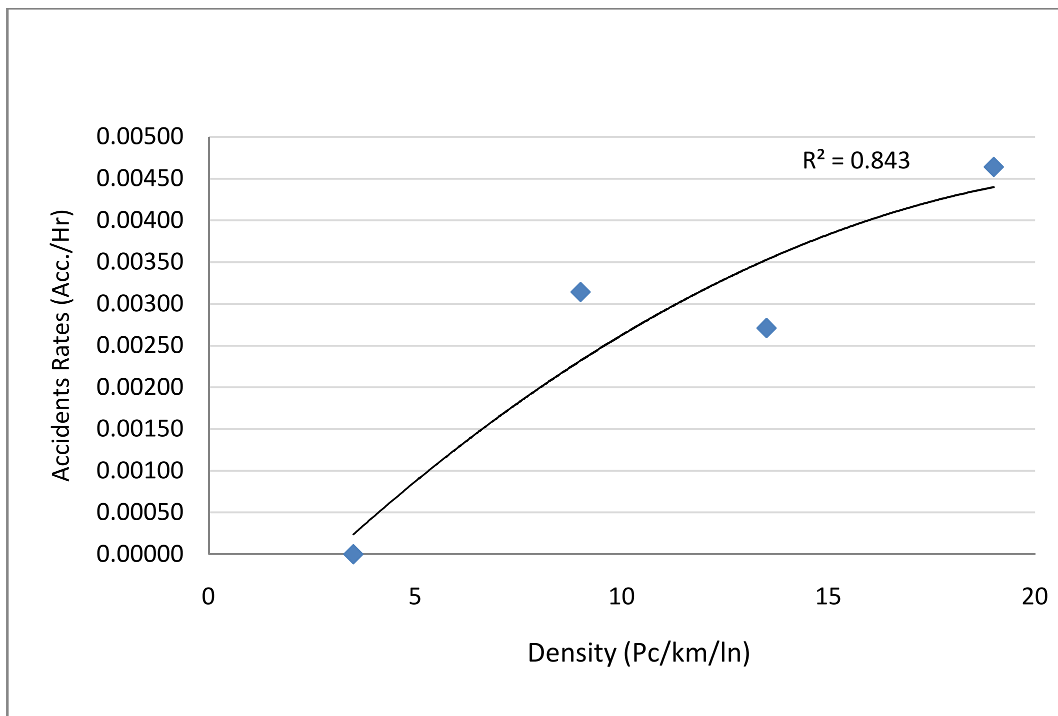


Figure 35: Al-Aqsa street rate of accidents distribution

4.4.1 Queen Alia Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-36 for Queen Alia Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows good correlation with R^2 value of 0.905.

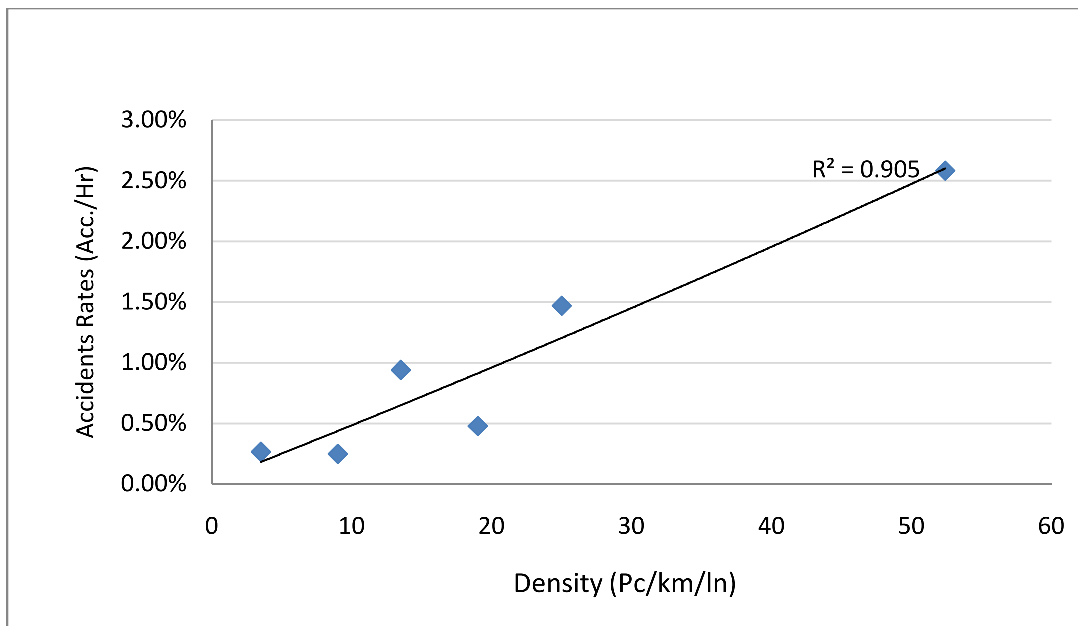


Figure 36: Queen Alia street rate of accidents distribution

4.4.2 Zahran Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-37 for Queen Alia Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows high correlation with R2 value of 0.855.

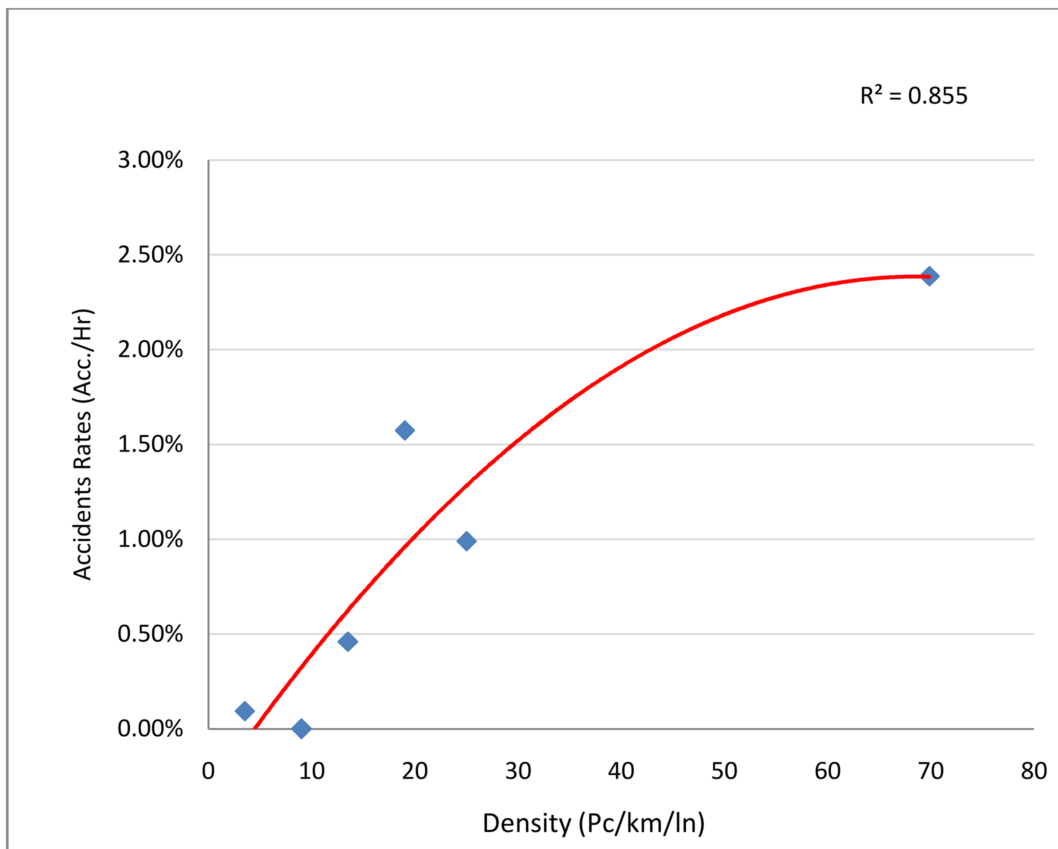


Figure 37: Zahran street rate of accidents distribution

4.4.3 Al-Yarmouk Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-38 for Queen Alia Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows good correlation with R2 value of 0.887.

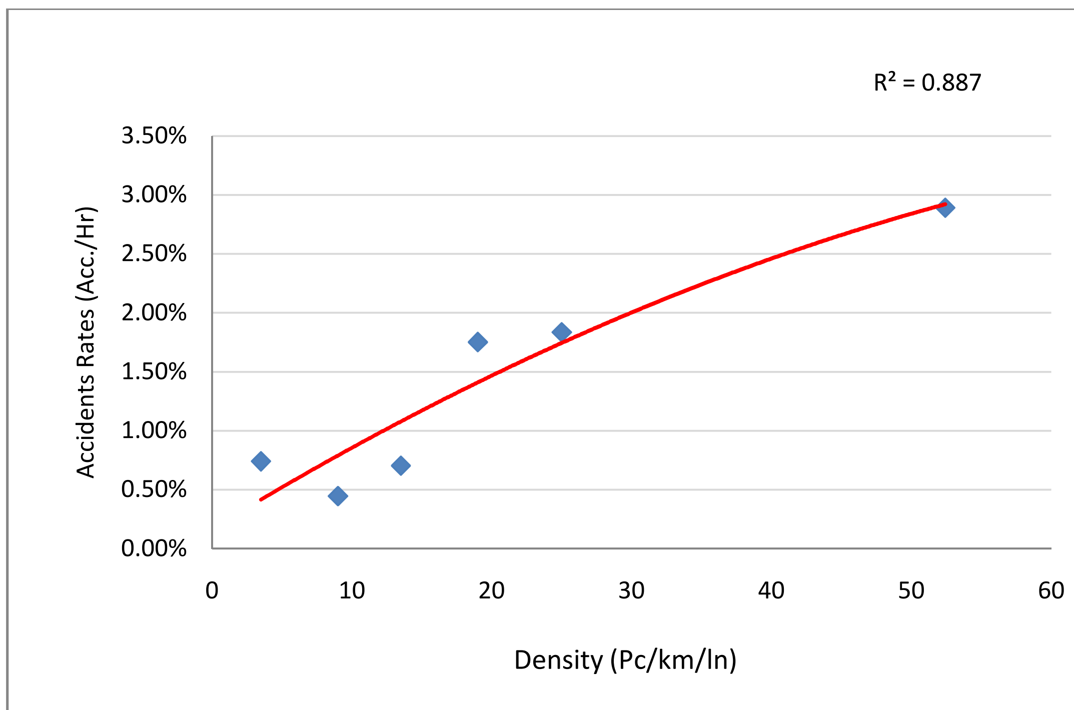


Figure 38: Al-Yarmouk street rate of accidents distribution

4.4.4 Al-Jaish Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-39 for Al-Jaish Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows high correlation with R2 value of 0.830.

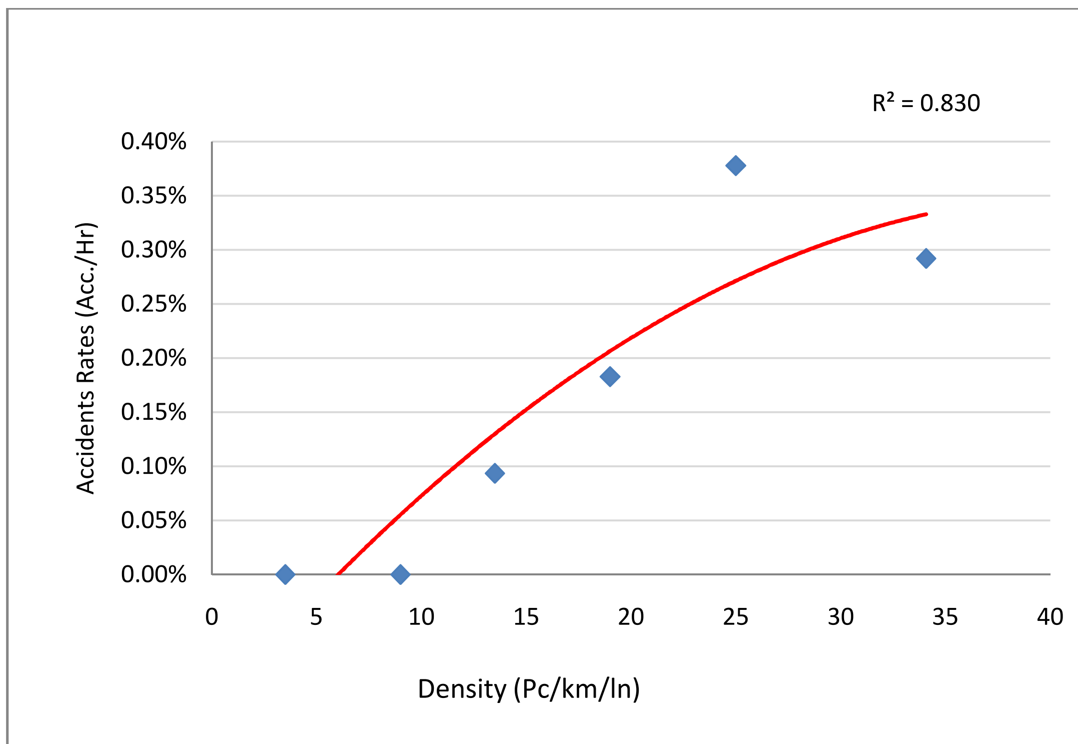


Figure 39: Al-Jaish Street rate of accidents distribution

4.4.5 Al-Shaheed Street

The number of accidents per hour of service under prevailing LOS expressed as rate of accidents is shown in Figure-40 for Al-Jaish Street. Using polynomial regression to predict the trend for the rate of accidents over different LOS shows high correlation with R2 value of 0.899.

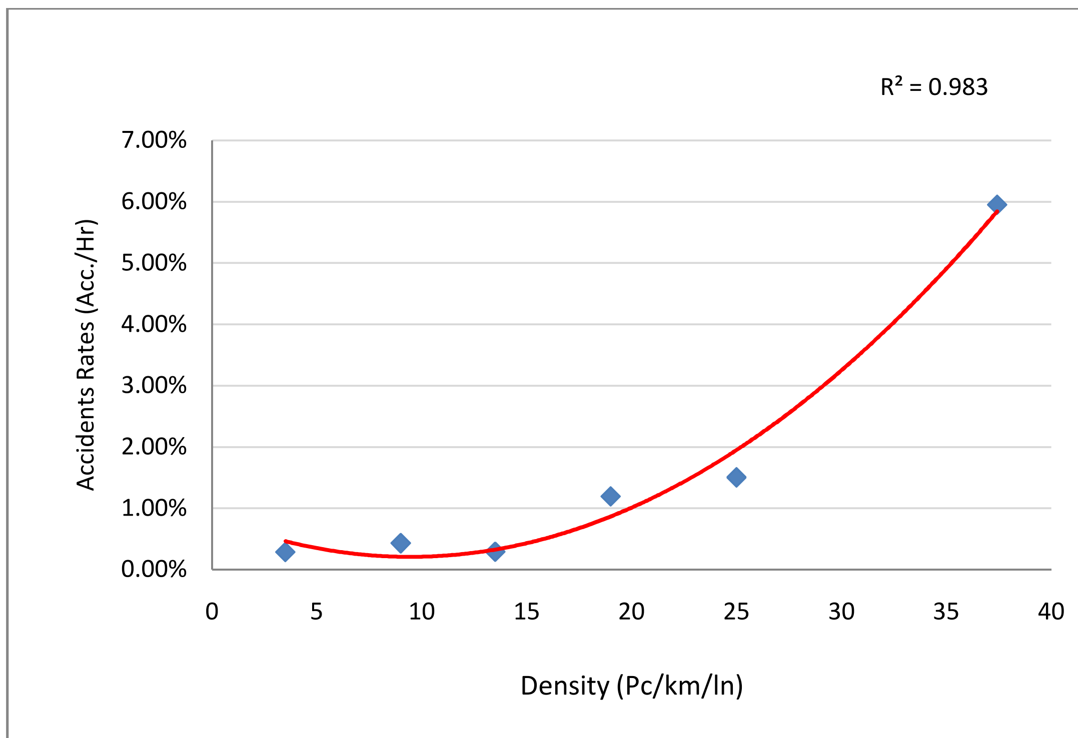


Figure 40: Al-Shaheed street rate of accidents distribution

5. Modeling

5. 1 Rate of accidents per hour

Figure-41 shows the rate of accidents per hour that correspond to the traffic density for all streets in this study. The individual rate of accidents for each LOS duration plotted on the right axis, while the total rate of accidents per total duration were plotted on the left axis. There is fair correlation between the density and the rate of accidents per hour, in the next sections, the rate of accidents per million vehicles will be introduced to enhance the accuracy of the accidents prediction model.

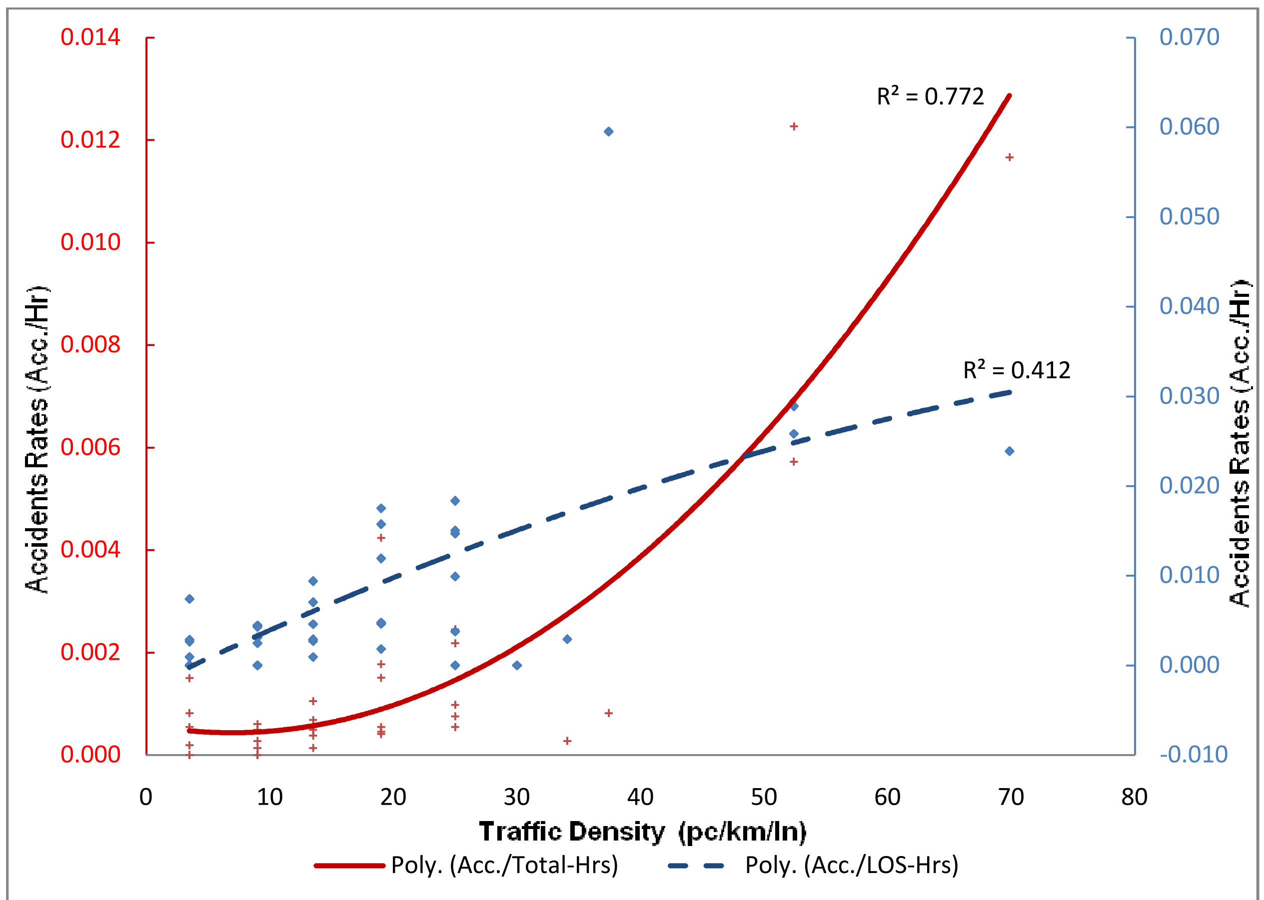


Figure 41: Scatter distribution for semiannual rate of accidents for Amman arterial

5. 2 LOS Occupancy

Based on a given ADT per lane under prevailing road conditions the LOS occupancy rate could be predicted for all Amman arterials. Table-5 shows the semiannual occupancy rate for all roads in this study.

Table-5: LOS Semiannual Occupancy Rate

LOS	A	B	C	D	E	F	ADT	Lanes	ADT/Lanes
Queen Alia	20.59%	5.49%	7.25%	8.56%	14.84%	43.27%	178,338	6	29723.08
Al-Aqsa	32.34%	19.13%	38.81%	9.71%	0.00%	0.00%	51,226	4	12806.46
Al-Jaish	23.70%	8.14%	14.58%	29.82%	14.43%	9.33%	99,263	6	16543.83
Al-Shaheed	28.45%	11.37%	16.80%	35.52%	6.50%	1.37%	132,635	6	22105.79
Al-Yarmouk	20.24%	6.11%	7.74%	10.11%	13.37%	42.44%	133,947	5	26789.36
Zahran	20.05%	5.78%	8.18%	9.56%	7.60%	48.83%	121,503	4	30375.75

The production of trend for Amman arterial LOS occupancy rate might be helpful in the following aspects:

- Estimation of the number of peak hours,
- Prediction of the total number of accidents for a given road section based on introduced model in this study.

Figure-43 used by starting from the horizontal axis with the semiannual ADT divided by total number of lanes and draw line vertically to intersect each level of service curve. The reading on the vertical axis give the percent of time for the intersected LOS occupancy, and the summation of all six reading give 100%.

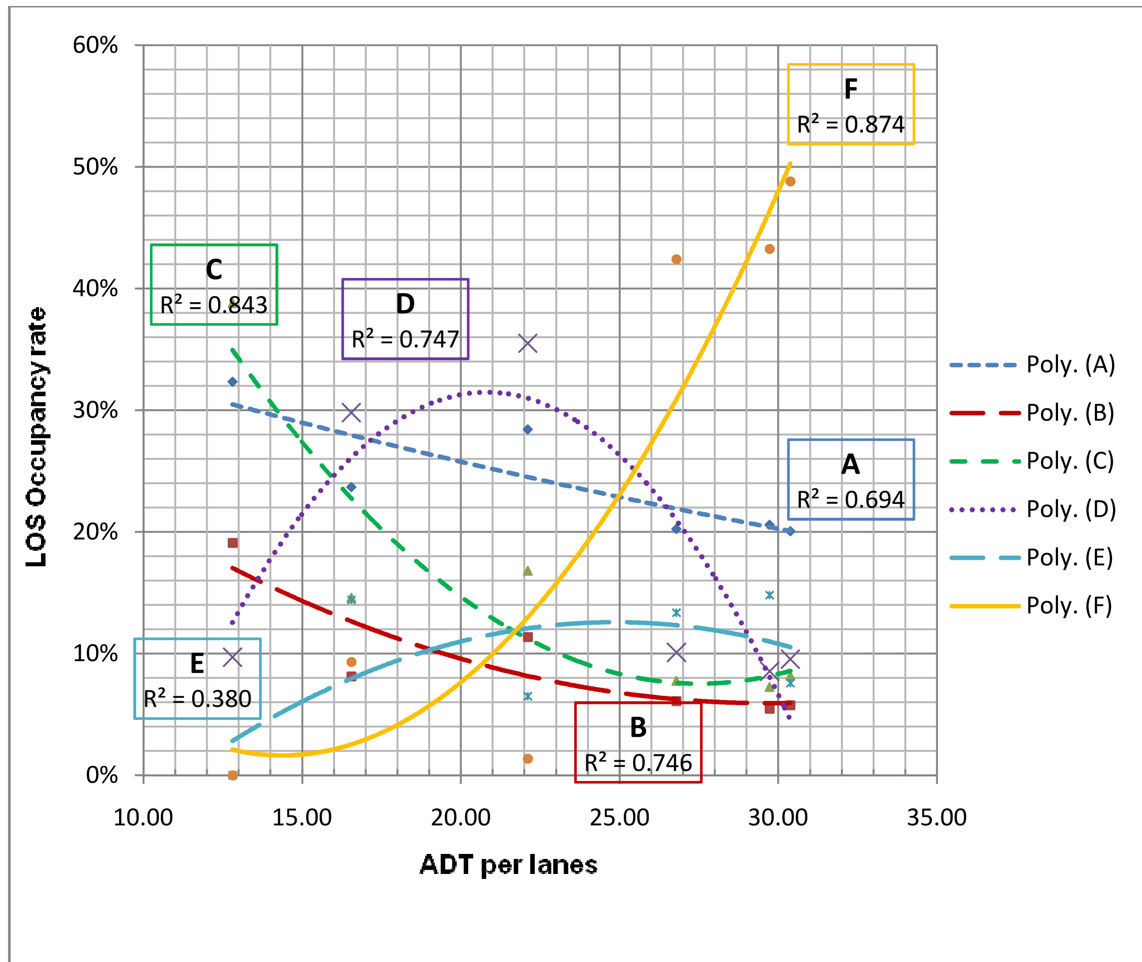


Figure 42: LOS ocupancy rate based on ADT/lane

For illustration purpose, let us consider Queen Alia road. The calculated semiannual ADT was equal to 178'338 vehicle/day, and when redistribute over the six available lanes, the result is 29'723 vehicle/day/lane. By drawing a vertical line intersecting the horizontal axis in Figure-42 at 29.7, the results for LOS occupancy rate will be 20.5%, 6.0%, 8.0%, 7.5%, 11.0% & 47.5% for LOS "A", "B", "C", "D", "E" & "F" respectively. The results percents were closed to the observations in Table-5.

5. 3 Rate of Accidents Model

The relationship between the rate of accidents (number of accidents per million traveled vehicle) and the roads' traffic density was developed and presented in Figure 43. The resulting model was as follow:

$A = 0.00230\ D^2 - 0.06496\ D + 0.60135$---------------- {1}

Where, A: is the accident rate (number of accidents per million vehicle),

D: Traffic Density (pc/km/ln) : $D = \frac{V_p}{S}$

Where, $V_p = \frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p}$

DDHV: Directional Design Hourly Volume

S: Operating speed (km/h)

V_p: flow rate (pc/h/ln)

P_{HF}: Peak hour factor

F_{HV}: Factor for heavy vehicles

f_p: Driver population factor

N: Number of lanes per direction

By including all these hidden parameter in formula number {1} the following new formula will results:

$A = 0.00230\ (\frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p \times S})^2 - 0.06496\ (\frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p \times S}) + 0.60135$ ---------{2}

The Coefficient of Determination R^2 was 0.906 and the model was validated with a new road data and the expected number of accidents was tested against the field observation using Root Mean Square Error (RMSE).

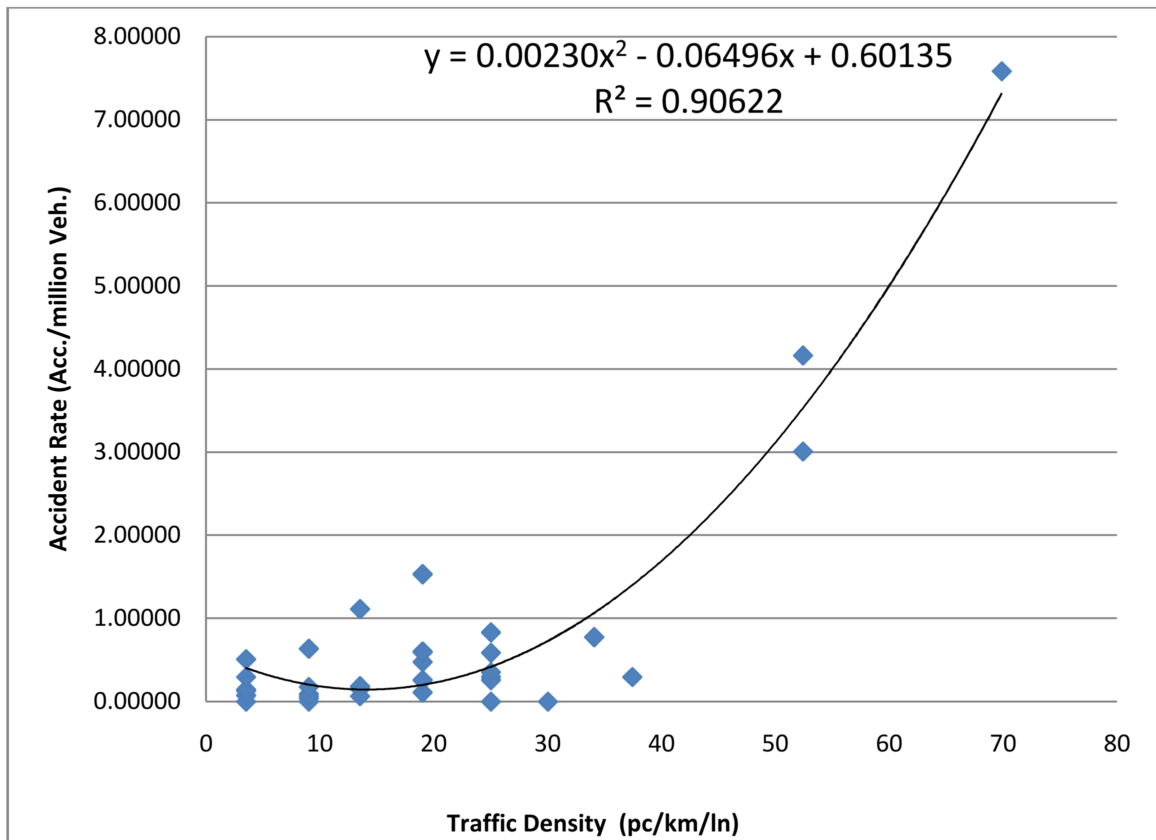


Figure 43: Modeling for street rate of accidents distribution

The given model in equation {2} provides the rate of accident per million vehicles for each LOS and not the total accidents for a given million traveled vehicle. Section 5.4 will reshape the model to provide the total accident per million traveled vehicle.

5. 4 Estimating Number of Accidents

The given model in section 5.3 provides the rate of accident per million vehicles for each LOS, while the total accidents for a given million traveled vehicle can be generated through aggregate the total fixed rates for LOS “A” to “E” and the resulting model will be based on the peak traffic density as show in formula {3}.

$A = 0.0023\,(D)^2 - 0.06496\;(D) + 1.9624$ ----------------- {3}

Where, A: is the accident rate (number of accidents per million vehicle),

D: Peak Traffic Density (pc/km/ln) : $D = \frac{V}{S}$

Where, $V_p = \frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p}$

S: Operating speed (km/h)

V_p: flow rate (pc/h/ln)

P_{HF}: Peak hour factor

F_{HV}: Factor for heavy vehicles

f_p: Driver population factor

N: Number of lanes per direction

DDHV: Directional Design-Hour Volume

By including all these hidden parameter in formula number {3} the following new formula will results:

$A = 0.0023\,\left(\frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p \times S}\right)^2 - 0.06496\;\left(\frac{\text{DDHV or V}}{P_{HF} \times N \times f_{HV} \times f_p \times S}\right) + 1.9624$ ------------{4}

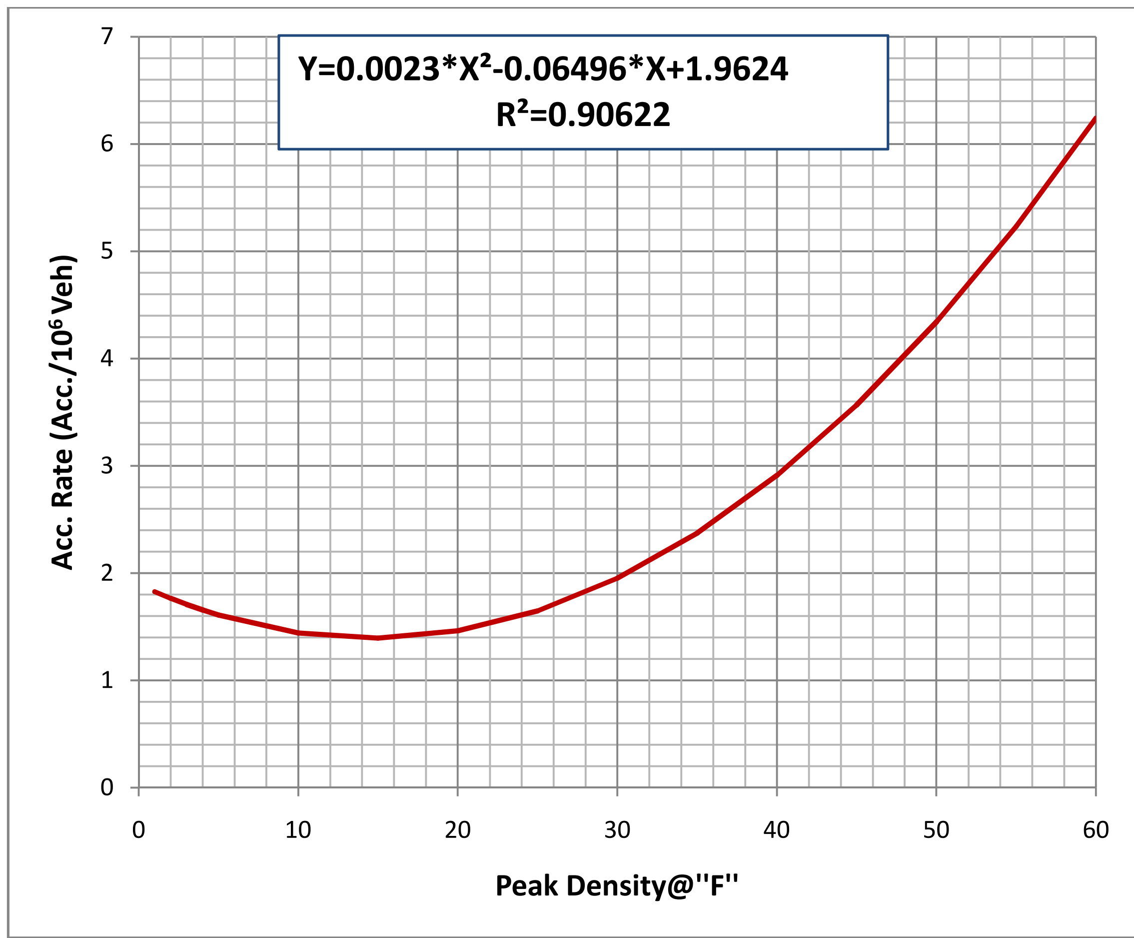


Figure 44: Accident Rate Vs Peak Density@"F"

A sample calculations and results are presented in Table-6.

Table-6: Expected Total Number of Accidents

Road	Density	Acc. Rate	10^6 Veh.	Est. Acc.	Obs. Acc.
Aqsa	0	1.96235	6.28797	12	14
Alia	52.40446681	4.874480561	27.25606	133	111
Zahran	69.86158594	8.649616115	13.451395	116	117
Yarmouk	52.41161975	4.875740316	21.615663	105	138
Jaish	34.06954301	2.418880137	15.468477	37	24
Shaheed	37.41952774	2.752085907	16.960667	47	48

5.5 Rate of Accidents Model validation

For the purpose of model validation, the model expected results (E_i) for the rate of accidents (number of accidents per million traveled vehicle) was compared against field observations (O_i) for King Abdullah.

The root mean square error (RMSE) used to calculate the difference between Actual and Predict values for the number of accidents as show in Table-7. The formula for RMSE given as following:

$$\text{RMSE} = \sqrt{\frac{(1^{st}\,error)^2 + (2^{nd}\,error)^2 + \dots + (n^{th}\,error)^2}{n-2}}$$

Table-7: Model Validation using Root mean square error (RMSE)

King Abdullah	Semiannual Accidents		
Density	O_i	E_i	error²
3.5	7	6.4	0.333
9	2	3.2	1.543
13.5	3	2.3	0.500
19	5	3.2	3.413
25	7	6.6	0.141
35	22	18.3	13.767
SUM	46	40.0248125	19.696
Degrees of Freedom	**4**	RSME	**2.21903**
Million Veh.	**15.97**		

6 Conclusions and Recommendations

6 .1 Conclusions

The relationship between LOS in term of traffic density and the rate of accidents per million vehicles was predicted and validated in this study. The resulting model was as follow:

$$A = 0.0023\,(D)^2 - 0.06496\,(D) + 1.9624$$

Where, A: is the accident rate (number of accidents per million vehicle),

D: Peak Hour Traffic Density (pc/km/ln)

The Coefficient of Determination R^2 was 0.906 and the model was tested using RMSE

The finding of this study, show that most of Amman arterials in this study have a prevailing LOS “F” for about 30% of the time, 55% of the accidents occur during LOS “F”. In other words, enhancing LOS from “F” to “E” only shall reduce the total number of accidents by 27%.

6 .2 **Recommendations**

Enhancing the LOS during peak hours along Amman arterials will reduce the total number of accidents. Recommendations to achieve this are summarized as follows:

- Increase the number of lanes where applicable,
- Modify the lane width to minimum of 3m in order to minimize the lateral friction between vehicles.
- Restrict the access of trucks and busses during the peak hours to main arterials.
- For a given number of lanes and traffic volume, operating speed can be significantly increased to enhance the LOS. Free flow Speed could be increased by modifying road cross sections and increasing the design speed and the speed limits.

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Appendices

A. Appendix A

Site ID:	AQSA	City:	Amman					
Site Reference:	I01	County:	Jordan					
Location:								
Start Date:	7/19/2010	Start Time:	12:00:00 AM					
End Date:	7/20/2010	End Time:	12:00:00 AM					
			Length of veh					
Date	Time	Lane	5.5 m	9m	13m	25m	>25m	
7/19/2010	12:15:00 AM	1	53	16	30	73	6	
7/19/2010	12:15:00 AM	2	15	18	13	52	1	
7/19/2010	12:15:00 AM	3	26	17	18	52	2	
7/19/2010	12:15:00 AM	4	16	7	8	36	1	
7/19/2010	12:30:00 AM	1	36	18	19	88	1	
7/19/2010	12:30:00 AM	2	22	17	6	59	0	
7/19/2010	12:30:00 AM	3	20	12	20	38	1	
7/19/2010	12:30:00 AM	4	10	12	6	28	1	
7/19/2010	12:45:00 AM	1	38	22	16	79	3	
7/19/2010	12:45:00 AM	2	15	18	10	40	0	
7/19/2010	12:45:00 AM	3	21	11	16	49	4	
7/19/2010	12:45:00 AM	4	11	11	5	23	0	
7/19/2010	1:00:00 AM	1	35	20	21	73	1	
7/19/2010	1:00:00 AM	2	16	20	14	37	1	
7/19/2010	1:00:00 AM	3	23	8	16	30	2	
7/19/2010	1:00:00 AM	4	3	5	3	19	0	
7/19/2010	1:15:00 AM	1	23	14	15	56	1	
7/19/2010	1:15:00 AM	2	8	5	5	15	0	
7/19/2010	1:15:00 AM	3	14	5	16	35	1	
7/19/2010	1:15:00 AM	4	16	3	13	13	0	
7/19/2010	1:30:00 AM	1	20	13	15	40	3	
7/19/2010	1:30:00 AM	2	6	5	5	17	0	
7/19/2010	1:30:00 AM	3	14	10	12	34	1	
7/19/2010	1:30:00 AM	4	8	4	3	14	0	
7/19/2010	1:45:00 AM	1	12	12	13	36	1	
7/19/2010	1:45:00 AM	2	6	4	5	10	0	
7/19/2010	1:45:00 AM	3	13	7	11	19	1	
7/19/2010	1:45:00 AM	4	3	7	1	12	0	

7/19/2010	2:00:00 AM	1	16	8	6	31	0
7/19/2010	2:00:00 AM	2	3	3	1	6	0
			Length of veh				
Date	Time	Lane	5.5m	9m	13m	25m	>25m
7/19/2010	2:00:00 AM	3	10	5	4	24	0
7/19/2010	2:00:00 AM	4	4	1	4	15	0
7/19/2010	2:15:00 AM	1	14	11	11	28	0
7/19/2010	2:15:00 AM	2	3	4	4	8	0
7/19/2010	2:15:00 AM	3	5	6	4	13	1
7/19/2010	2:15:00 AM	4	6	1	1	8	0
7/19/2010	2:30:00 AM	1	7	7	7	24	0
7/19/2010	2:30:00 AM	2	3	1	1	6	0
7/19/2010	2:30:00 AM	3	6	3	5	14	0
7/19/2010	2:30:00 AM	4	3	0	4	6	0
7/19/2010	2:45:00 AM	1	8	3	6	16	0
7/19/2010	2:45:00 AM	2	0	3	1	4	0
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7/19/2010	3:30:00 AM	2	0	0	1	2	0
7/19/2010	3:30:00 AM	3	8	3	2	10	0
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7/19/2010	4:15:00 AM	4	1	1	0	1	0
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7/19/2010	5:30:00 AM	1	3	1	3	8	0
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7/19/2010	5:30:00 AM	4	1	0	1	5	0
7/19/2010	5:45:00 AM	1	1	0	4	8	0
7/19/2010	5:45:00 AM	2	0	0	0	0	0
7/19/2010	5:45:00 AM	3	6	6	3	12	0
7/19/2010	5:45:00 AM	4	4	2	3	4	0
7/19/2010	6:00:00 AM	1	6	5	5	8	1
7/19/2010	6:00:00 AM	2	1	0	1	1	0
7/19/2010	6:00:00 AM	3	8	5	2	15	0
7/19/2010	6:00:00 AM	4	2	4	1	2	1
7/19/2010	6:15:00 AM	1	8	2	6	23	1
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7/19/2010	6:15:00 AM	4	4	6	1	7	0
7/19/2010	6:30:00 AM	1	18	14	6	30	0
7/19/2010	6:30:00 AM	2	0	3	0	11	0
7/19/2010	6:30:00 AM	3	15	5	10	26	0
7/19/2010	6:30:00 AM	4	4	5	5	11	0
7/19/2010	6:45:00 AM	1	16	16	19	41	0
7/19/2010	6:45:00 AM	2	3	5	11	20	0
7/19/2010	6:45:00 AM	3	21	11	12	45	1
7/19/2010	6:45:00 AM	4	16	12	7	20	0
7/19/2010	7:00:00 AM	1	28	13	16	50	1
7/19/2010	7:00:00 AM	2	11	10	8	20	2
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7/19/2010	7:15:00 AM	1	35	18	13	78	2
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7/19/2010	7:15:00 AM	3	57	20	18	90	4
7/19/2010	7:15:00 AM	4	36	22	17	55	1
7/19/2010	7:30:00 AM	1	55	30	21	62	1
7/19/2010	7:30:00 AM	2	23	17	16	55	1
7/19/2010	7:30:00 AM	3	43	22	22	94	2
7/19/2010	7:30:00 AM	4	28	24	16	63	1

7/19/2010	7:45:00 AM	1	56	34	26	71	1
7/19/2010	7:45:00 AM	2	36	20	20	72	0
7/19/2010	7:45:00 AM	3	51	26	23	95	0
7/19/2010	7:45:00 AM	4	37	20	19	79	1
7/19/2010	8:00:00 AM	1	50	26	22	77	2
7/19/2010	8:00:00 AM	2	46	26	28	68	2
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7/19/2010	8:00:00 AM	4	25	34	11	70	0
7/19/2010	8:15:00 AM	1	44	23	28	82	3
7/19/2010	8:15:00 AM	2	29	18	22	64	0
7/19/2010	8:15:00 AM	3	41	27	26	86	2
7/19/2010	8:15:00 AM	4	27	19	21	78	2
7/19/2010	8:30:00 AM	1	46	36	21	68	0
7/19/2010	8:30:00 AM	2	32	23	13	60	0
7/19/2010	8:30:00 AM	3	56	23	27	88	5
7/19/2010	8:30:00 AM	4	45	33	23	81	1
7/19/2010	8:45:00 AM	1	44	26	22	74	2
7/19/2010	8:45:00 AM	2	23	28	17	55	2
7/19/2010	8:45:00 AM	3	60	26	29	101	5
7/19/2010	8:45:00 AM	4	34	19	24	61	1
7/19/2010	9:00:00 AM	1	42	25	33	81	3
7/19/2010	9:00:00 AM	2	24	21	13	52	1
7/19/2010	9:00:00 AM	3	55	27	34	100	4
7/19/2010	9:00:00 AM	4	45	19	23	67	1
7/19/2010	9:15:00 AM	1	35	25	20	89	3
7/19/2010	9:15:00 AM	2	18	14	24	46	3
7/19/2010	9:15:00 AM	3	63	23	29	96	1
7/19/2010	9:15:00 AM	4	38	19	16	76	3
7/19/2010	9:30:00 AM	1	40	22	30	97	3
7/19/2010	9:30:00 AM	2	24	22	16	52	2
7/19/2010	9:30:00 AM	3	37	24	27	94	2
7/19/2010	9:30:00 AM	4	30	14	11	67	0
7/19/2010	9:45:00 AM	1	49	21	23	74	3
7/19/2010	9:45:00 AM	2	21	22	26	65	3
7/19/2010	9:45:00 AM	3	52	16	25	95	2
7/19/2010	9:45:00 AM	4	25	18	18	64	0
7/19/2010	10:00:00 AM	1	41	26	25	80	1
7/19/2010	10:00:00 AM	2	30	29	16	72	0
7/19/2010	10:00:00 AM	3	51	28	24	121	2
7/19/2010	10:00:00 AM	4	35	26	22	56	1
7/19/2010	10:15:00 AM	1	47	31	26	98	3
7/19/2010	10:15:00 AM	2	21	29	15	62	2
7/19/2010	10:15:00 AM	3	36	27	28	80	4
7/19/2010	10:15:00 AM	4	35	16	21	63	1
7/19/2010	10:30:00 AM	1	55	22	30	76	3
7/19/2010	10:30:00 AM	2	20	27	20	64	1
7/19/2010	10:30:00 AM	3	46	31	31	99	3

7/19/2010	10:30:00 AM	4	42	13	21	50	0
7/19/2010	10:45:00 AM	1	40	21	24	87	6
7/19/2010	10:45:00 AM	2	19	29	13	51	3
7/19/2010	10:45:00 AM	3	44	23	35	96	3
7/19/2010	10:45:00 AM	4	31	20	19	60	1
7/19/2010	11:00:00 AM	1	44	22	36	88	2
7/19/2010	11:00:00 AM	2	20	25	23	88	2
7/19/2010	11:00:00 AM	3	51	16	34	89	1
7/19/2010	11:00:00 AM	4	30	22	15	53	1
7/19/2010	11:15:00 AM	1	54	33	28	94	5
7/19/2010	11:15:00 AM	2	26	19	20	84	1
7/19/2010	11:15:00 AM	3	45	29	25	97	2
7/19/2010	11:15:00 AM	4	38	17	19	74	0
7/19/2010	11:30:00 AM	1	52	32	33	101	5
7/19/2010	11:30:00 AM	2	29	32	20	92	0
7/19/2010	11:30:00 AM	3	39	27	39	105	5
7/19/2010	11:30:00 AM	4	31	20	17	65	2
7/19/2010	11:45:00 AM	1	57	30	36	99	0
7/19/2010	11:45:00 AM	2	29	23	28	61	3
7/19/2010	11:45:00 AM	3	38	25	30	103	1
7/19/2010	11:45:00 AM	4	26	23	15	69	3
7/19/2010	12:00:00 PM	1	58	29	32	76	3
7/19/2010	12:00:00 PM	2	22	24	16	72	1
7/19/2010	12:00:00 PM	3	56	27	28	99	0
7/19/2010	12:00:00 PM	4	34	18	15	74	3
7/19/2010	12:15:00 PM	1	52	24	30	100	4
7/19/2010	12:15:00 PM	2	21	32	18	63	0
7/19/2010	12:15:00 PM	3	51	30	37	82	1
7/19/2010	12:15:00 PM	4	26	29	16	73	2
7/19/2010	12:30:00 PM	1	50	35	23	94	1
7/19/2010	12:30:00 PM	2	24	29	24	74	2
7/19/2010	12:30:00 PM	3	43	21	21	90	1
7/19/2010	12:30:00 PM	4	27	15	14	65	0
7/19/2010	12:45:00 PM	1	57	24	38	111	3
7/19/2010	12:45:00 PM	2	29	39	20	77	1
7/19/2010	12:45:00 PM	3	56	20	31	97	1
7/19/2010	12:45:00 PM	4	23	24	26	74	0
7/19/2010	1:00:00 PM	1	70	28	30	102	3
7/19/2010	1:00:00 PM	2	30	33	32	84	2
7/19/2010	1:00:00 PM	3	42	20	20	103	1
7/19/2010	1:00:00 PM	4	30	24	26	61	1
7/19/2010	1:15:00 PM	1	48	27	32	114	4
7/19/2010	1:15:00 PM	2	42	37	23	83	4
7/19/2010	1:15:00 PM	3	41	25	30	96	2
7/19/2010	1:15:00 PM	4	26	18	14	65	2
7/19/2010	1:30:00 PM	1	56	26	36	111	1
7/19/2010	1:30:00 PM	2	21	33	21	84	1

7/19/2010	1:30:00 PM	3	51	18	30	109	4
7/19/2010	1:30:00 PM	4	30	22	26	74	3
7/19/2010	1:45:00 PM	1	76	41	35	98	3
7/19/2010	1:45:00 PM	2	40	32	22	90	4
7/19/2010	1:45:00 PM	3	54	19	30	73	4
7/19/2010	1:45:00 PM	4	32	17	26	50	1
7/19/2010	2:00:00 PM	1	54	40	32	109	5
7/19/2010	2:00:00 PM	2	34	46	25	75	5
7/19/2010	2:00:00 PM	3	44	22	19	66	1
7/19/2010	2:00:00 PM	4	20	13	16	81	2
7/19/2010	2:15:00 PM	1	60	21	35	125	1
7/19/2010	2:15:00 PM	2	37	50	32	97	1
7/19/2010	2:15:00 PM	3	46	25	30	87	2
7/19/2010	2:15:00 PM	4	43	25	21	77	1
7/19/2010	2:30:00 PM	1	63	32	44	122	2
7/19/2010	2:30:00 PM	2	43	41	19	101	1
7/19/2010	2:30:00 PM	3	47	26	20	83	4
7/19/2010	2:30:00 PM	4	27	26	16	67	1
7/19/2010	2:45:00 PM	1	57	35	41	123	4
7/19/2010	2:45:00 PM	2	43	43	26	100	2
7/19/2010	2:45:00 PM	3	40	29	30	82	6
7/19/2010	2:45:00 PM	4	26	23	9	71	1
7/19/2010	3:00:00 PM	1	57	44	48	115	0
7/19/2010	3:00:00 PM	2	42	37	30	109	5
7/19/2010	3:00:00 PM	3	45	25	24	88	2
7/19/2010	3:00:00 PM	4	36	27	17	70	1
7/19/2010	3:15:00 PM	1	68	45	38	112	2
7/19/2010	3:15:00 PM	2	54	50	30	119	1
7/19/2010	3:15:00 PM	3	41	23	26	94	2
7/19/2010	3:15:00 PM	4	38	21	26	75	2
7/19/2010	3:30:00 PM	1	68	38	30	118	6
7/19/2010	3:30:00 PM	2	45	45	25	88	4
7/19/2010	3:30:00 PM	3	57	26	25	94	1
7/19/2010	3:30:00 PM	4	30	25	11	61	0
7/19/2010	3:45:00 PM	1	61	31	40	133	1
7/19/2010	3:45:00 PM	2	58	42	30	123	1
7/19/2010	3:45:00 PM	3	29	27	21	94	1
7/19/2010	3:45:00 PM	4	19	18	20	52	1
7/19/2010	4:00:00 PM	1	55	27	27	122	5
7/19/2010	4:00:00 PM	2	44	38	27	85	1
7/19/2010	4:00:00 PM	3	50	20	26	87	0
7/19/2010	4:00:00 PM	4	25	21	17	59	6
7/19/2010	4:15:00 PM	1	56	40	36	146	4
7/19/2010	4:15:00 PM	2	45	40	31	109	2
7/19/2010	4:15:00 PM	3	38	24	27	86	3
7/19/2010	4:15:00 PM	4	29	19	15	60	2
7/19/2010	4:30:00 PM	1	66	35	42	119	3

7/19/2010	4:30:00 PM	2	39	37	34	85	3
7/19/2010	4:30:00 PM	3	45	24	20	93	4
7/19/2010	4:30:00 PM	4	29	23	19	56	1
7/19/2010	4:45:00 PM	1	59	31	45	123	4
7/19/2010	4:45:00 PM	2	39	45	29	83	4
7/19/2010	4:45:00 PM	3	38	17	21	81	2
7/19/2010	4:45:00 PM	4	21	19	14	46	2
7/19/2010	5:00:00 PM	1	54	37	36	111	1
7/19/2010	5:00:00 PM	2	36	29	31	104	1
7/19/2010	5:00:00 PM	3	30	22	27	89	4
7/19/2010	5:00:00 PM	4	25	18	14	43	3
7/19/2010	5:15:00 PM	1	71	36	37	116	4
7/19/2010	5:15:00 PM	2	37	41	32	110	2
7/19/2010	5:15:00 PM	3	41	19	29	92	5
7/19/2010	5:15:00 PM	4	25	24	18	57	2
7/19/2010	5:30:00 PM	1	74	37	33	116	2
7/19/2010	5:30:00 PM	2	45	41	22	106	4
7/19/2010	5:30:00 PM	3	35	26	24	83	3
7/19/2010	5:30:00 PM	4	23	21	19	52	0
7/19/2010	5:45:00 PM	1	54	40	40	95	3
7/19/2010	5:45:00 PM	2	43	40	30	81	2
7/19/2010	5:45:00 PM	3	51	21	33	79	1
7/19/2010	5:45:00 PM	4	36	20	19	61	1
7/19/2010	6:00:00 PM	1	85	48	36	116	3
7/19/2010	6:00:00 PM	2	76	46	38	125	5
7/19/2010	6:00:00 PM	3	55	14	24	85	5
7/19/2010	6:00:00 PM	4	26	15	21	69	0
7/19/2010	6:15:00 PM	1	50	33	32	128	4
7/19/2010	6:15:00 PM	2	45	42	23	89	8
7/19/2010	6:15:00 PM	3	44	23	30	95	1
7/19/2010	6:15:00 PM	4	34	23	24	52	3
7/19/2010	6:30:00 PM	1	54	32	48	101	0
7/19/2010	6:30:00 PM	2	35	30	31	106	3
7/19/2010	6:30:00 PM	3	38	30	14	89	2
7/19/2010	6:30:00 PM	4	19	16	20	61	0
7/19/2010	6:45:00 PM	1	72	34	28	138	3
7/19/2010	6:45:00 PM	2	47	42	39	109	1
7/19/2010	6:45:00 PM	3	59	23	29	91	4
7/19/2010	6:45:00 PM	4	39	17	32	47	2
7/19/2010	7:00:00 PM	1	47	29	43	120	2
7/19/2010	7:00:00 PM	2	47	30	34	108	4
7/19/2010	7:00:00 PM	3	44	31	26	110	2
7/19/2010	7:00:00 PM	4	28	15	20	69	0
7/19/2010	7:15:00 PM	1	65	40	30	118	2
7/19/2010	7:15:00 PM	2	55	36	27	118	2
7/19/2010	7:15:00 PM	3	43	26	26	98	2
7/19/2010	7:15:00 PM	4	25	17	14	65	1

7/19/2010	7:30:00 PM	1	59	37	35	115	2
7/19/2010	7:30:00 PM	2	58	40	35	106	3
7/19/2010	7:30:00 PM	3	65	21	36	111	1
7/19/2010	7:30:00 PM	4	30	28	24	74	1
7/19/2010	7:45:00 PM	1	64	34	27	107	2
7/19/2010	7:45:00 PM	2	44	33	32	87	1
7/19/2010	7:45:00 PM	3	57	26	41	116	3
7/19/2010	7:45:00 PM	4	41	26	27	79	3
7/19/2010	8:00:00 PM	1	64	26	33	128	8
7/19/2010	8:00:00 PM	2	58	44	37	89	1
7/19/2010	8:00:00 PM	3	45	31	28	109	2
7/19/2010	8:00:00 PM	4	38	22	25	81	1
7/19/2010	8:15:00 PM	1	61	37	37	129	1
7/19/2010	8:15:00 PM	2	40	34	30	110	6
7/19/2010	8:15:00 PM	3	40	25	29	93	0
7/19/2010	8:15:00 PM	4	27	30	18	80	2
7/19/2010	8:30:00 PM	1	62	34	30	131	6
7/19/2010	8:30:00 PM	2	62	44	24	102	2
7/19/2010	8:30:00 PM	3	41	30	37	95	2
7/19/2010	8:30:00 PM	4	38	15	25	80	3
7/19/2010	8:45:00 PM	1	74	37	40	115	5
7/19/2010	8:45:00 PM	2	39	37	30	120	4
7/19/2010	8:45:00 PM	3	49	23	36	117	2
7/19/2010	8:45:00 PM	4	42	26	26	79	3
7/19/2010	9:00:00 PM	1	83	23	37	111	1
7/19/2010	9:00:00 PM	2	59	34	20	112	4
7/19/2010	9:00:00 PM	3	48	16	34	103	1
7/19/2010	9:00:00 PM	4	37	18	20	72	0
7/19/2010	9:15:00 PM	1	61	36	38	133	6
7/19/2010	9:15:00 PM	2	53	34	31	114	2
7/19/2010	9:15:00 PM	3	54	23	33	97	1
7/19/2010	9:15:00 PM	4	22	28	25	64	1
7/19/2010	9:30:00 PM	1	69	44	33	136	0
7/19/2010	9:30:00 PM	2	69	47	34	139	3
7/19/2010	9:30:00 PM	3	54	30	31	108	4
7/19/2010	9:30:00 PM	4	34	20	28	74	2
7/19/2010	9:45:00 PM	1	62	36	32	141	5
7/19/2010	9:45:00 PM	2	52	31	32	111	1
7/19/2010	9:45:00 PM	3	42	24	23	91	2
7/19/2010	9:45:00 PM	4	38	12	16	64	0
7/19/2010	10:00:00 PM	1	55	25	31	126	3
7/19/2010	10:00:00 PM	2	39	22	32	78	2
7/19/2010	10:00:00 PM	3	28	28	29	74	4
7/19/2010	10:00:00 PM	4	30	17	20	54	0
7/19/2010	10:15:00 PM	1	53	33	38	109	2
7/19/2010	10:15:00 PM	2	35	41	31	71	1
7/19/2010	10:15:00 PM	3	29	20	25	86	4

7/19/2010	10:15:00 PM	4	28	13	9	57	1
7/19/2010	10:30:00 PM	1	53	31	22	117	4
7/19/2010	10:30:00 PM	2	47	20	30	80	0
7/19/2010	10:30:00 PM	3	37	23	34	71	3
7/19/2010	10:30:00 PM	4	26	19	13	48	1
7/19/2010	10:45:00 PM	1	46	31	30	114	3
7/19/2010	10:45:00 PM	2	43	34	14	75	3
7/19/2010	10:45:00 PM	3	44	26	30	94	1
7/19/2010	10:45:00 PM	4	23	23	17	69	0
7/19/2010	11:00:00 PM	1	74	22	28	102	2
7/19/2010	11:00:00 PM	2	40	31	22	64	2
7/19/2010	11:00:00 PM	3	51	26	31	103	3
7/19/2010	11:00:00 PM	4	24	22	22	67	0
7/19/2010	11:15:00 PM	1	60	34	29	105	5
7/19/2010	11:15:00 PM	2	43	40	22	71	4
7/19/2010	11:15:00 PM	3	42	19	29	93	0
7/19/2010	11:15:00 PM	4	28	19	11	53	2
7/19/2010	11:30:00 PM	1	52	37	22	84	1
7/19/2010	11:30:00 PM	2	24	31	17	62	1
7/19/2010	11:30:00 PM	3	39	20	30	82	3
7/19/2010	11:30:00 PM	4	30	13	18	45	0
7/19/2010	11:45:00 PM	1	48	28	27	87	1
7/19/2010	11:45:00 PM	2	25	18	15	64	3
7/19/2010	11:45:00 PM	3	30	17	29	66	2
7/19/2010	11:45:00 PM	4	25	10	9	48	2
7/20/2010	12:00:00 AM	1	49	25	12	85	2
7/20/2010	12:00:00 AM	2	16	22	13	48	2
7/20/2010	12:00:00 AM	3	35	21	20	68	2
7/20/2010	12:00:00 AM	4	16	15	16	45	1

B. Appendix B

Sample LOS and Accident Data for Queen Alia Street one direction

DATE	TIME	DDHV	Density	LOS	Accidents	Injuries
7/8/2010	1:00 PM	10762	72.74128	F	1	no
7/14/2010	1:00 AM	5454	27.13272	E	1	no
7/14/2010	9:00 AM	11613	84.37576	F	1	yes
7/17/2010	8:00 AM	5650	28.31379	F	1	no
7/19/2010	6:00 PM	10521	69.76832	F	1	no
7/21/2010	5:00 PM	9856	62.18658	F	1	no
7/26/2010	11:00 PM	4252	20.42216	D	1	no
7/27/2010	8:00 AM	4923	24.05706	E	1	no
7/27/2010	11:00 AM	5692	28.57022	F	1	no
8/4/2010	9:00 PM	4582	22.17392	E	1	no
8/8/2010	11:00 AM	5876	29.70791	F	2	no
8/8/2010	7:00 PM	5045	24.74811	E	1	no
8/11/2010	9:00 AM	5726	28.77868	F	1	yes
8/12/2010	11:00 AM	5638	28.24074	F	1	no
8/14/2010	5:00 AM	385	1.844068	A	1	yes
8/15/2010	9:00 PM	4001	19.16394	D	1	no
8/15/2010	10:00 PM	4158	19.93831	D	1	no
8/23/2010	2:00 PM	5870	29.67044	F	1	no
8/24/2010	10:00 AM	5676	28.47239	F	1	no

العلاقة بين مستوى الخدمة ونسبة حوادث الطرق الشريانية في عمان

إعداد

محمد سعيد عبدالرحمن الغنانيم

المشرف

الاستاذ الدكتور عدلي البلبيسي

ملخــــــــــــــــص

تدرس هذه الاطروحة العلاقه بين مستوى الخدمه ومعدل الحوادث من اشتقاق معادله من خلال دراسه مجموعه طرق شريانيه في العاصمة عمان. قدمت اجراءات معينه وتوصيات لضمان أمان الطرق تحت مستويات الخدمة المختلفة للطريق. وذلك من خلال دراسه العلاقه بين معدل الحوادث ومستوى كثافه المرور (مستوى الخدمه للطريق).

تم تحديد فترة الدراسة لمدة ستة شهور من تموز الى كانون الاول للعام 2010 م لتوفير المعلومات المرورية لمحطات الرصد المروري التابعة للامانة عمان الكبرى.

تبين من خلال هذه الدراسة ان معظم الطرق يسود فيها مستوى الخدمة (F) بنسبة 30% من الوقت ويشمل هذه المستوى على 55% من الحوادث. لذا تم اقتراح محاولة تحسين مستوى الخدمة للشوارع الشريانية في العاصمة عمان بحيث ان تحسين مستوى الخدمة من (F) الى (E) يساهم في تخفيض معدل الحوادث بنسبة 27%.

من خلال هذة الدراسة تم ايجاد العلاقة التالية لمعدل الحوادث :

$$A = 0.0023\ (D)^2 - 0.06496\ (D) + 1.9624$$

A: نسبة الحوادث لكل مليون سيارة

D: كثافة المرور